PUBLIC LIBRARY, DETROIT

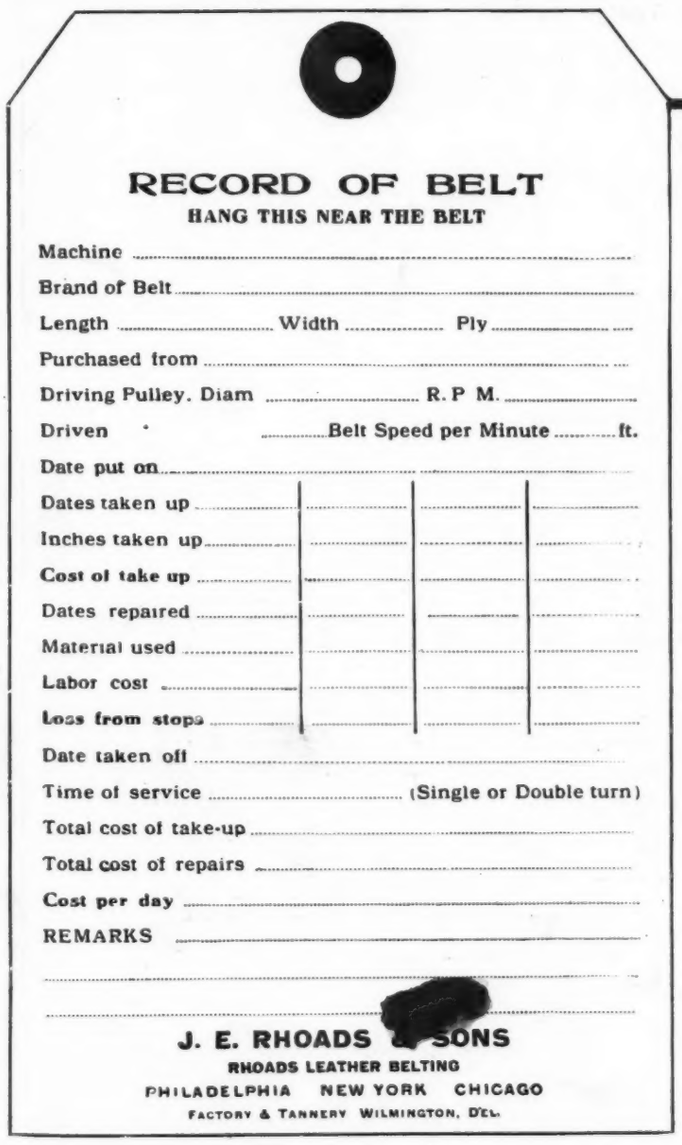
May 9, 1911.

POWER

Issued Weekly by the Hill Publishing Company, 505 Pearl St., New York

Price 5 Cents, $2.00 per Year

Contents 747. Advertising Index 62



RHOADS

TANNATE
TRADE MARK
REG. IN U.S. PAT. OFF.

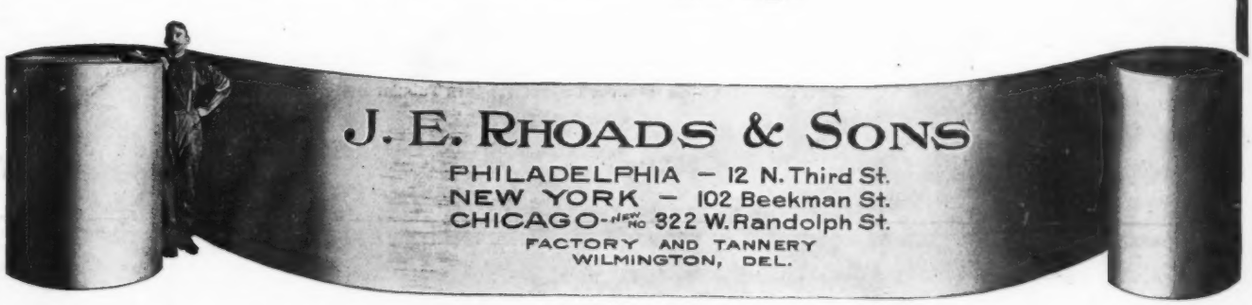
BELTING

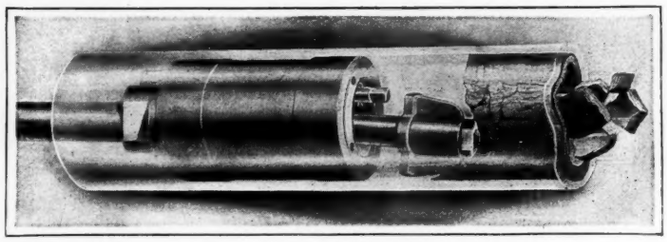
Do you know how much different makes of belting cost you? Most people do not.

Many people can see 5% saving in the first cost, but do not see 20% to 40% saving in results given.

We offer tag forms as pictured, but larger, for keeping records of our belts and of any others in comparison.

Test the results of Rhoads Belts on your next need, and ask for the tags.


J. E. RHOADS & SONS
PHILADELPHIA — 12 N. Third St.
NEW YORK — 102 Beekman St.
CHICAGO — NEW NO 322 W. Randolph St.
FACTORY AND TANNERY
WILMINGTON, DEL.



The Dean Removing Scale from the Tube of a Water Tube Boiler.

Let Us Loan You A Dean For A Thorough Trial In One Boiler

If we can't prove that you do have scale in spite of what you may now be doing to combat it, and

If we can't prove that the Dean removes scale more thoroughly, with greater ease, in less time, at smaller cost, than any other device on the market, you may box it up and return it at our expense.

This is not a bluff to create a favorable impression—not a proposition with a string to it—

It's a straight proposition that thousands of steam users have investigated—and found profitable.

One man, for instance, writes us that the use of the Dean has enabled him to save $50.00 a month—the tribute he formerly paid to the compound man.

Another man—an engineer—says the Dean reduced the coal bill $4.00 a week on two boilers.

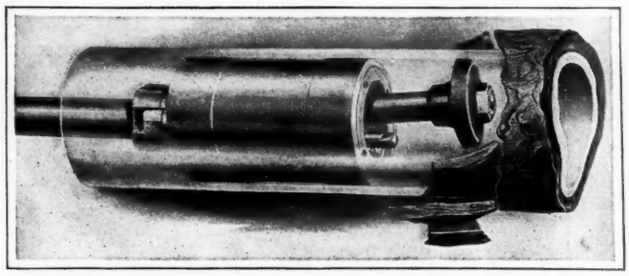
The manager of one of the largest lumber manufactories on the Pacific Coast states that the Dean put a stop to leaky tubes—a trouble which the engineer had been unable to overcome.

Why not send for a Dean today?

The Wm. B. Pierce Company

CHICAGO OFFICE
801 Steinway Building

Jewett Bldg., Buffalo, N. Y.



The Dean Removing Scale from the Tube of a Return Tubular Boiler.

POWER

NEW YORK, MAY 9, 1911

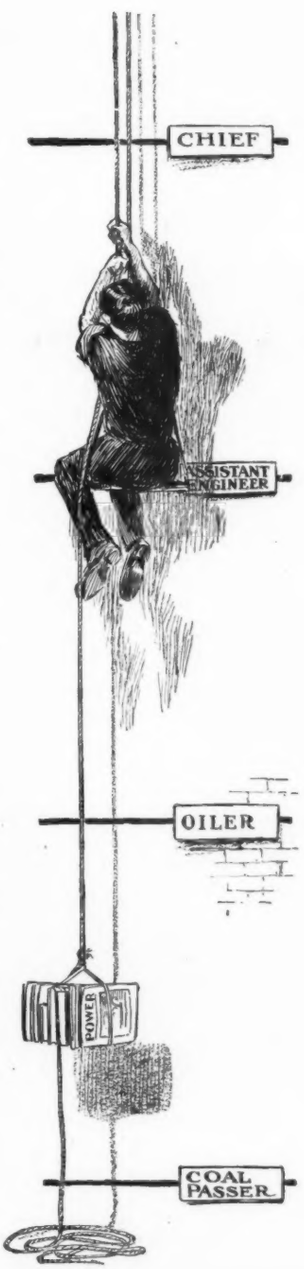
AMBITION is, in all cases, the mainspring of the action which leads to success, and nothing worth while is ever accomplished without it.

There are instances of the peculiar fitness of some men for particular lines of work. The accomplishments of these men are often labeled the work of geniuses. But upon even superficial examination it is found that their achievements are the results of persistent effort.

Genius has been characterized by someone as nothing beyond a capacity for hard work.

In the everyday life of the engineer may be found almost numberless illustrations of this. Among the employees about the power plant of a large cotton mill in New England some years ago, there was an undersized and rather frail young man wheeling coal from the yard to the boiler room. Thinking little or nothing of the man except that to all appearances he was a misfit for the job, the chief engineer suggested that he try to get work in the weave shed as it was perhaps more suited to his physical strength.

Answering the suggestion the young man said: "I am well satisfied at present, although the work is near the limit of my strength, but I do not intend to be a coal passer all my life. I expect to be the chief engineer of this mill, or a bigger one, perhaps, so it will not hurt me to know how coal should be handled."



With the position of chief engineer as his goal the young man bent all of his energy to the task of fitting himself for it. Step by step he conquered each difficulty and when the chief who had advised the seeking of a lighter task resigned, this man with a definite aim in life was selected to take the place.

This is not an unusual story. It is only one from thousands which are never told.

Every change is rung upon the achievements of Watt, Corliss and Edison, while the more modest attainments of humbler workers are never mentioned. So, the worker grows into the habit of thinking that only great things are worth a struggle.

The coal passer chose a goal within the reach of men of average mental equipment and made that goal the chief object of his life. His was not an uncommon success because his aim was not unusually high, but it shows that with a fixed aim a man may compel opportunities by preparing for them.

There is nothing between any man and his goal, no obstacle to overcome, no barriers to be broken except himself. He alone sets the limits by which attainment is measured.

Not all men are possessed of a desire to stand so much above their fellows. Not every soldier can be a general or even a major, but each should cherish, at least, the ambition to be among the best of his class.

Municipal Pumping and Power Plant

By Warren O. Rogers

In this plant at Orange, N. J., alternating current is generated to drive induction motors coupled to direct-current arc machines. Two 3,000,000-gallon water works pumping engines with no atmospheric exhaust are installed. Both engines and pumps are run condensing without the aid of circulating pumps, the water being bypassed through the condensers from the suction pipe.

After several years of litigation, the city of Orange, N. J., has installed its own electric-lighting plant, which it is now operating. In 1908 a new pumping plant was built and enough boilers were installed to operate a city lighting plant; an engine room was also reserved between the boiler and pump rooms. The Public Service Corporation of New Jersey, however, was naturally opposed to the installation of a municipal plant as it would mean a loss of $28,500 per year to them, so they zealously fought the project.

They instituted proceedings against the city which delayed matters until February 13 of this year, when the current was cut off from the lines of the Public Service Corporation. With this event the price of $85 per lamp per year for 340 arc street lamps became a thing of the past.

The red-brick building housing the machinery is located on Chestnut street and as one turns the corner to enter the boiler room, the brick coal-storage house is seen. This building is divided into six compartments, each capable of holding 40 tons, or a total of 240 tons of coal. All fuel is carted to the storage house and is then loaded into a one-ton car that runs on an industrial railway. When run into the boiler room each car of coal is weighed on a Hunt platform scale.

Boilers

There are four Heine boilers, each of 225 horsepower capacity. They are set in one battery and each furnace is provided with a grate area of 52 square feet. Fig. 1 represents a view of the boilers and a partial view of the piping above them. Fig. 2 shows the piping arrangement more in detail. There is but one outlet from the steam drum of each boiler. To this outlet a tee connection is secured and an Ashton pop-spring safety valve is bolted to the top outlet. To the side outlet a stop valve is attached and to this valve a long-radius bend connects with the header which runs over the rear of the four boilers. At the central point of this header is a tee to which the main steam pipe, with a stop valve in the line close to the boiler header, connects. This line runs up over the economizer and through the wall between the boiler and engine rooms and dropping down, connects to a header in the engine

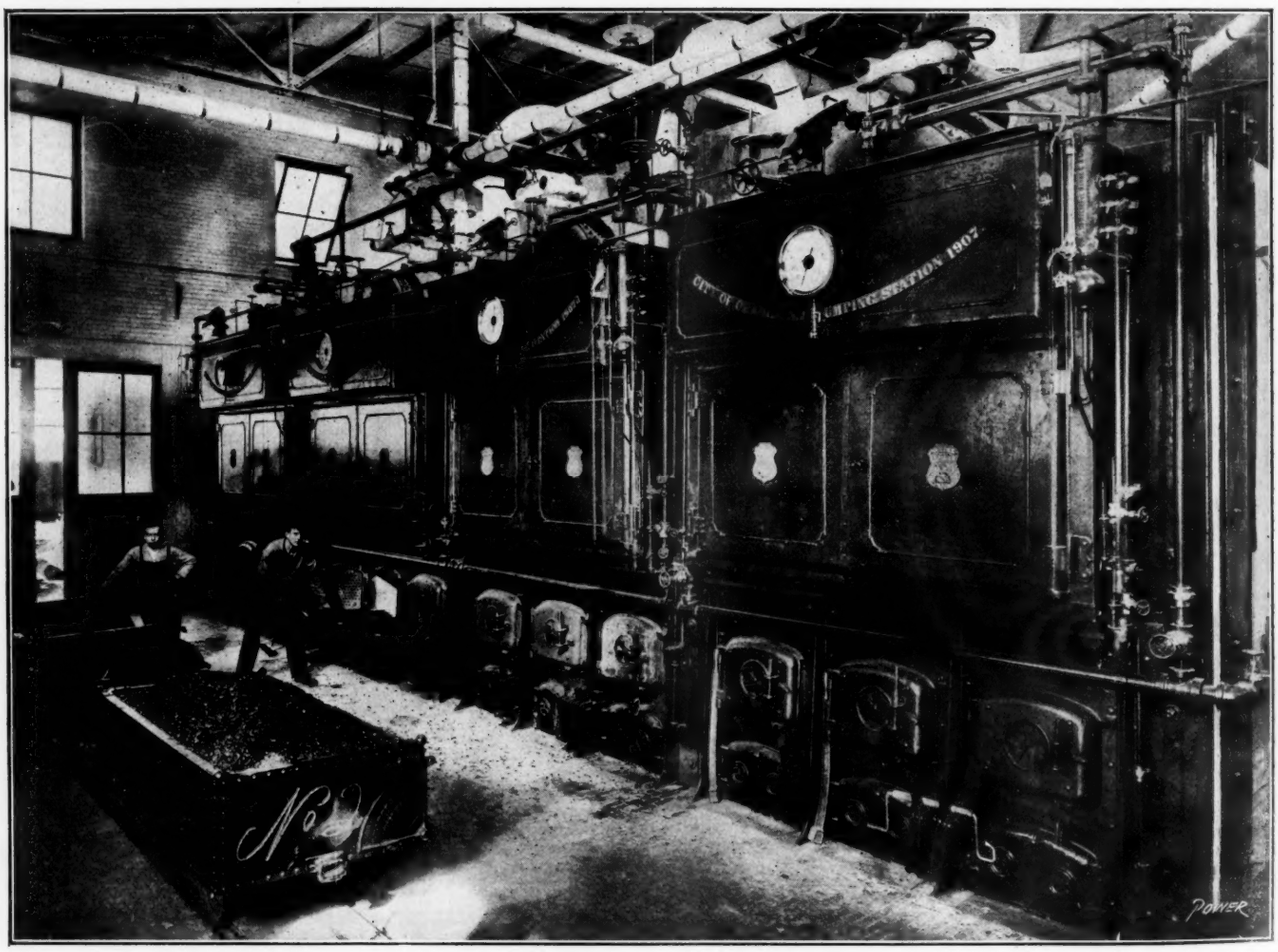


Fig. 1. Boiler Room of the Orange, N.J., Municipal Electric-light Plant

room. From this header the main feed pipes pass down through the engine-room floor and are run under the floor to the two large engines.

At the opposite end of the header a pipe is connected and runs across the end of the engine room with branches to the two pumps in the pump room.

The boilers are hand fired, and No. 1 buckwheat is burned. The average water evaporation for the last month was eight pounds per pound of coal. A steam pressure of 150 pounds per square inch is carried. Two boilers easily carry the night load. One boiler, if run to its capacity, would supply steam for operating the large service pump that is run continuously, but operating conditions make it more economical to run two boilers during the day than banking the fires under one and breaking the fire out for the night load. The two working boilers are, therefore, run light during the day and are ready for the night load when required, without the loss of fuel which the other method would entail.

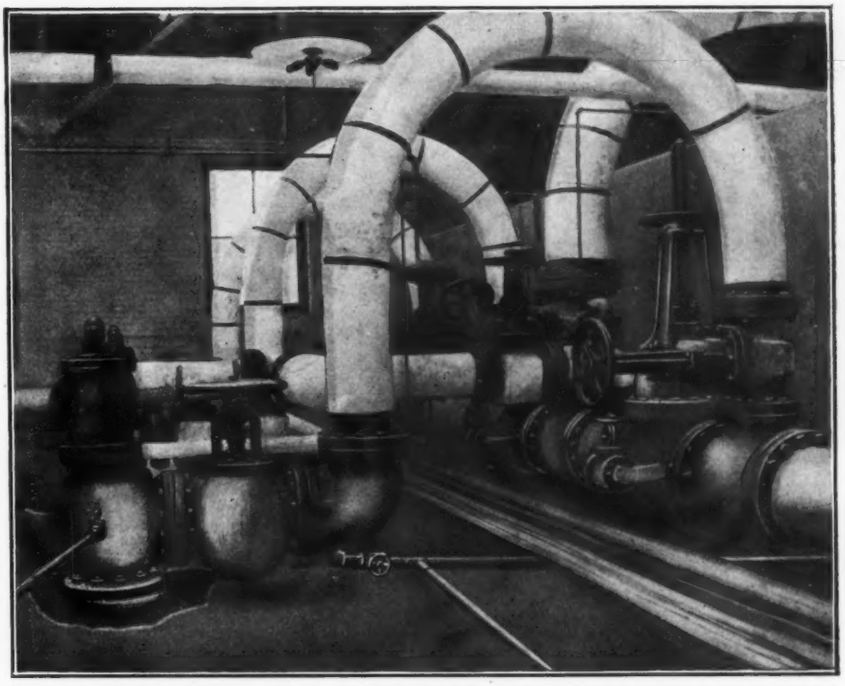


FIG. 2. PIPING OVER THE BOILERS

ECONOMIZER

A Greene fuel economizer is located at the rear of the boilers. It contains 252 four-inch by 8-foot tubes. The feed water is passed through a feed-water heater and is heated by the steam from the exciter engine when it is running or by the steam from the boiler-feed pump, and the vacuum pump, the latter operating when the engines are running. As the economizer is designed for four boilers and as but two are used, the feed water is at present heated to but 170 degrees Fahrenheit.

A smoke flue reaches across the back end of the boiler on top and one end is connected with the smoke passage to the

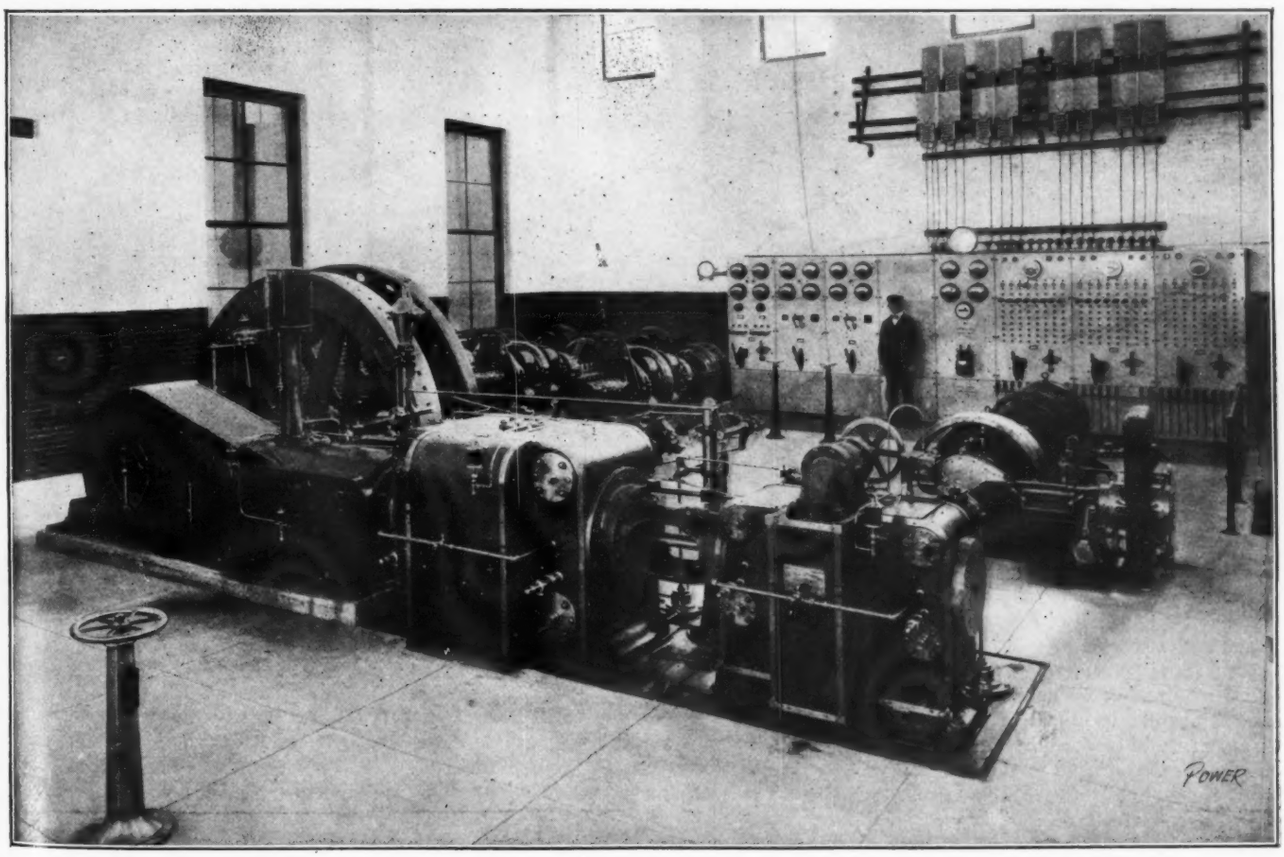


FIG. 3. PARTIAL VIEW OF THE ENGINE ROOM SHOWING DIRECT-CURRENT ARC MACHINES IN THE FAR CORNER

economizer. The other end is connected directly with a 175-foot Keeler radial-brick chimney, the base of which is 9 feet and the top 6 feet inside diameter.

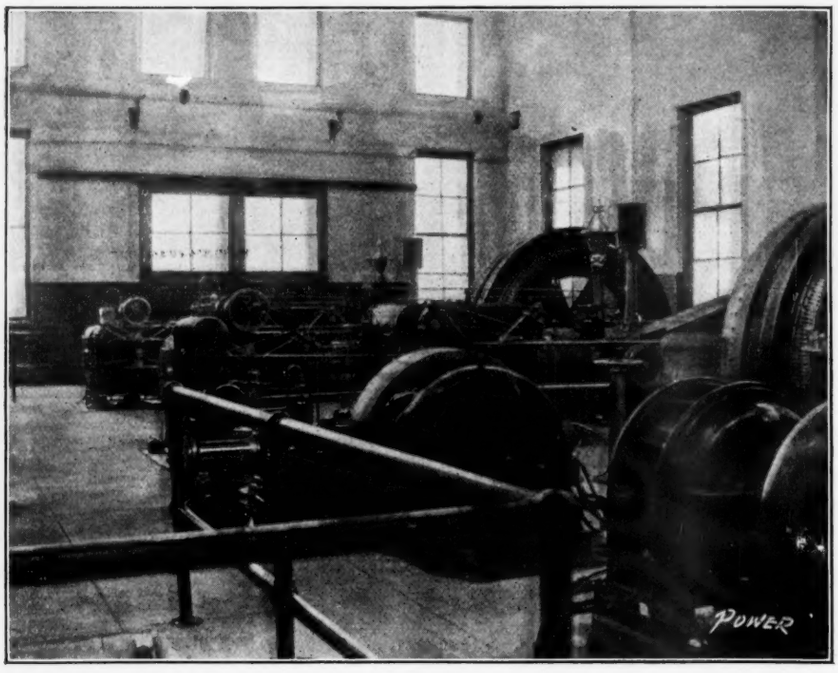


FIG. 4. ANOTHER VIEW OF THE ENGINE ROOM

Natural draft is used, although a Greene engine and fan-blowing set is installed in the blower room adjoining the base of the stack. Air-ducts running to the boiler setting have also been constructed.

ENGINE ROOM

Passing into the engine room, a view of which is shown in Figs. 3 and 4, one is confronted by two Hewes & Phillips' engines, 11 and 22x30-inch tandem-compound Corliss engines. Each runs at a speed of 150 revolutions; this high speed is practical, due to the new Franklin valve gear with which both engines are equipped. Each engine is direct coupled to a two-phase 250-kilovolt-ampere, 2200-volt Fort Wayne alternating-current generator. Contrary to general practice these machines do not deliver electrical energy outside of the building, but generate energy for three Fort Wayne induction motors which drive five arc machines. Two of these motors are of 120 horsepower capacity and are each coupled, by means of two flexible insulated couplings, to two Brush 9000-volt 4-ampere arc generators, which run at a speed of 700 revolutions per minute. The third motor is of 60 horsepower capacity and is coupled to one arc machine of the same capacity as the others. The grouping of these machines is shown in Fig. 3.

The coupling between the motor and generator shafts is shown in Fig. 5. It consists of a flange mounted on each shaft to be coupled together. Each flange has four arms which are made with a rim about 4 inches wide. Between the eight arms of the two coupling flanges are placed four pieces of round rubber. They are prevented from working out at the top of the arm by the overlap of the rim face and from working out at the side by flat plates which are secured to each arm of the coupling, by means of screws.

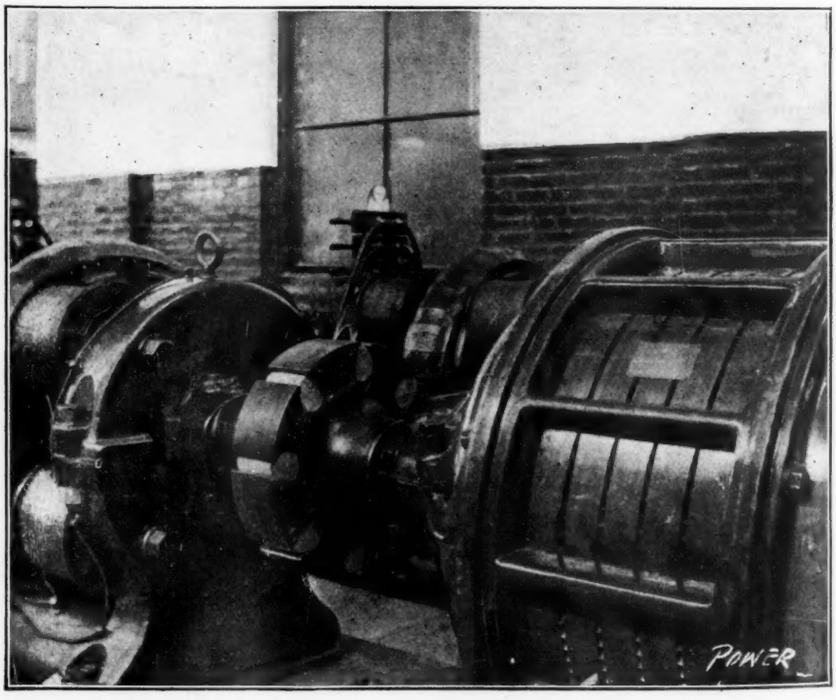


FIG. 5. METHOD OF COUPLING MOTOR AND GENERATOR TOGETHER

EXCITER UNITS

There are two exciter units. One consists of a 15-kilowatt, 125-volt direct-current Wood generator which is directly coupled to a Flemming automatic engine, running at 350 revolutions per minute. The other unit consists of one 25-kilowatt, 125-volt direct-current Wood generator, directly coupled to a 40-horsepower induction motor, running at 900 revolutions per minute.

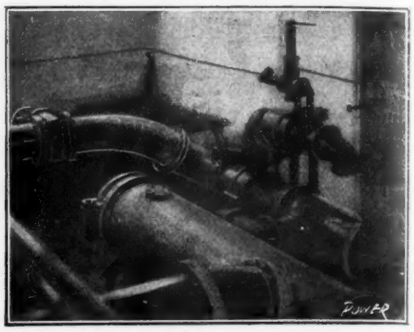


FIG. 7. RELIEF VALVE ON SUCTION PIPE OF PUMPS

SWITCHBOARD

The switchboard is made up of seven panels of blue Vermont marble. Three are used for the plug switches of the arc-light circuits, two for the generators, one for the exciters and one is a spare panel for an extra generator unit, for which space is provided. The machine panels have the usual recording and indicating instruments, switches and other devices.

PUMPS

Beyond the engine room is the pump room, in which there are two Snow

pumping engines, each of 3,000,000 gallons water capacity per 24 hours at 39 revolutions per minute. These pumps deliver city water to a 6,000,000-gallon storage reservoir against a 288-foot head. But one pump operates at a time. Both pumps run condensing. In fact, they can run in no other way, as neither is fitted with an atmospheric exhaust pipe. Fig. 6 shows two views of the pumps.

At one time considerable trouble was experienced by excessive pressure in the suction line of the pumps. This pressure would occur when the valve gear on the pumping engine failed to engage once or twice in succession, or when carelessly shutting down. As the pump takes the water from the suction pipe about as fast as it can flow by gravity, due to a 49-foot fall from the source of supply, the pressure was built up in excess of 90 pounds per square inch. To eliminate this dangerous condition, Chief Engineer Berg decided to put in a relief valve on the suction line. Accordingly a 7-inch Lombard relief valve was installed, as shown in Fig. 7. It is set to operate at 25 pounds pressure per square inch on the suction pipe and so the danger from a pressure greater than this is eliminated.

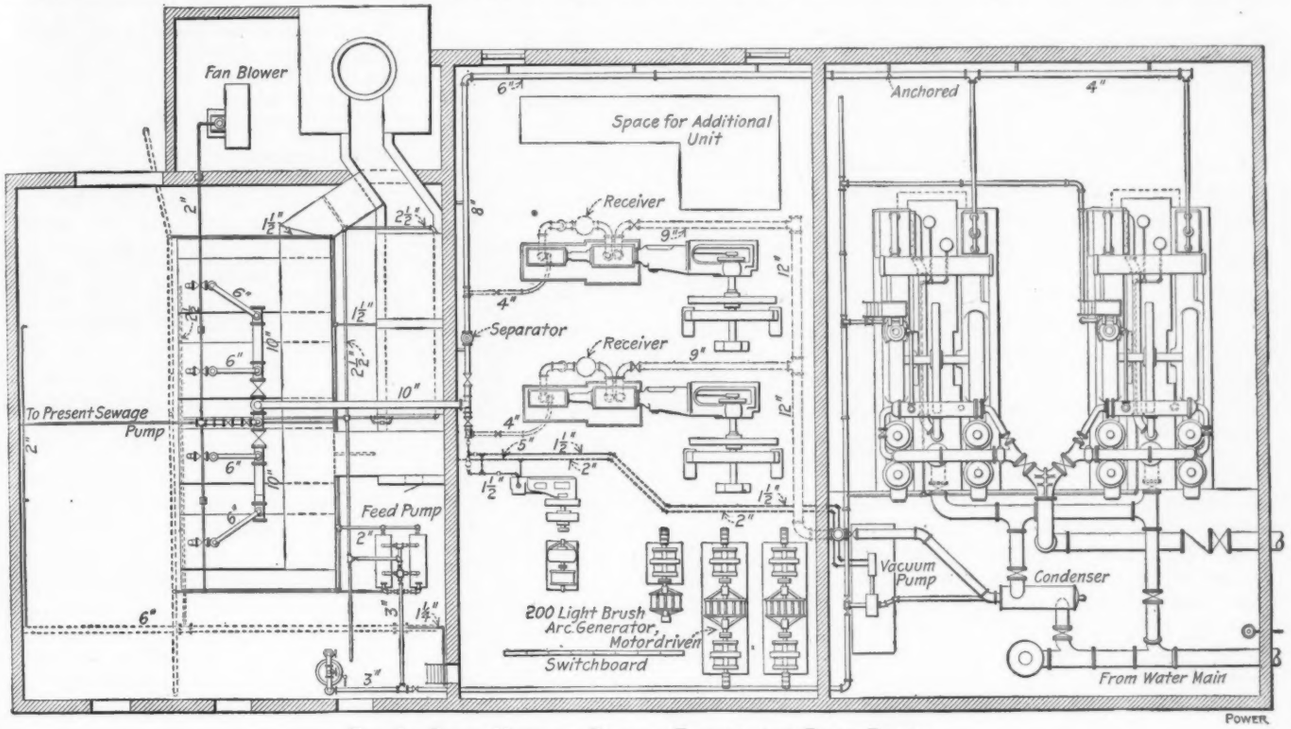


FIG. 8. PLAN VIEW OF BOILER, ENGINE AND PUMP ROOMS

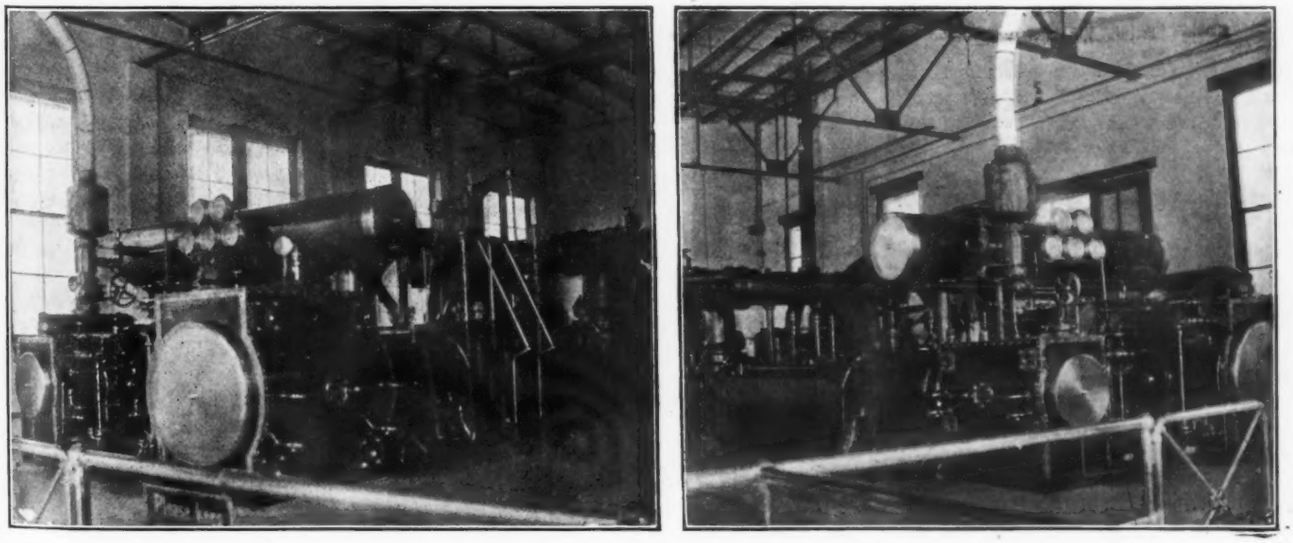


FIG. 6. VIEWS OF THE TWO LARGE PUMPING ENGINES

CONDENSERS

The principal generating units and the pumps are operated condensing, but the arrangement of the condenser differs from that found in most power plants. A Worthington surface condenser is placed on a stand made of pipes and is located in the basement of the pump room. No circulating pump is used, but a vacuum of 26½ inches is easily maintained. The exhaust steam enters the condenser at one end and surrounds the tubes within the shell. The cooling water is drawn from the suction pipe of the large service pump and is passed through the tubes of the condenser, reëntering the suction pipe at the other end. The inches of vacuum are regulated by means of a valve in the bypass pipe leading to the condenser.

This novel method of supplying cooling water eliminates the first cost of a circulating pump and also the expense of its operation. As one of the pumping engines is always in operation, circulating water for the condenser is always available.

A similar arrangement is also carried out in working both of the large pumps. The condenser, however, is located above the water end of each pump, as shown in Fig. 6. In the case of the pumps, however, the exhaust steam passes through the condenser tubes. They are surrounded by the water and passing through the condenser, the condensing waters enter the discharge pipe of the pump and mix with the water which is pumped for domestic use. One would at first suppose that this arrangement would affect the temperature of the city water, but as the rise is but 4 degrees in the summer time, it is not objectionable. The condensed water from the pump surface condenser discharges the condensed water by gravity to a hotwell from which it is pumped to the boilers by one of the two Knowles 7½ and 5x6-inch outside packed feed pumps. They are both located at the rear of the boiler setting, as shown in Fig. 8, which is a plain view of the entire plant. Fig. 9 shows a side elevation of the power apparatus.

The condensation from the engine condenser is handled by a Burnham 8 and 12 by 12 vacuum pump, which is placed in the basement pit at the rear end of the pump room.

Another feature not found in most power plants is the Worthington recording liquid weigher. It is so connected that the water of condensation taken from the engine condenser can be automatically weighed and the steam consumption determined without preparation.

At present there are 374 arc lamps on the various circuits, as against 340 that were carried by the Public Service Corporation. There are also 145 incandescent lamps placed in series.

Owing to the short time this plant has been in operation no figures are available for comparison as to the cost of operating the street lights under the two systems. Later on, when figures for comparison are available, it will be possible to compare the costs under a municipally operated electric-lighting plant and a private central station.

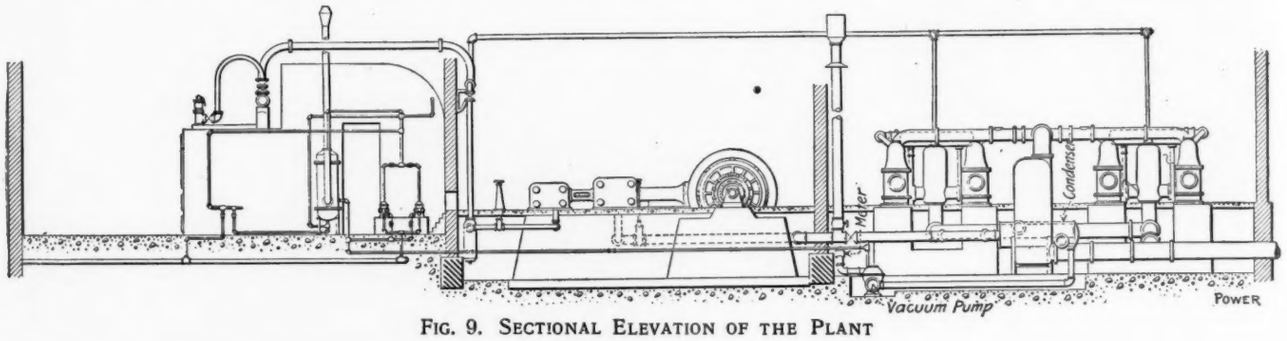


FIG. 9. SECTIONAL ELEVATION OF THE PLANT

High Boiler Efficiency with Oil Fuel

By Frank T. Clarke

A series of tests upon one of the boilers of the Redondo plant of the Pacific Light and Power Company, using crude oil as fuel and showing an average efficiency of 80.47 per cent.

When the Redondo plant of the Pacific Light and Power Company was built a few years ago it attracted considerable attention, owing to the fact that reciprocating engines were selected as prime movers instead of turbines. The main units are each of 5000 kilowatts capacity and are arranged on the panel system. Each panel consists of six oil-fired Babcock & Wilcox boilers supplying steam at 175 pounds and 100 degrees superheat to a double horizontal and vertical McIntosh & Seymour compound-condensing engine running at 100 revolutions per minute, the latter direct connected to a three-phase, 50-cycle, 18,000-volt generator.

In December, 1908, a paper was read before the American Society of Mechanical Engineers, giving the figures of a test upon this plant which showed an exceptionally high overall efficiency. But, as the figures represented the performance of the complete plant, it was impossible to separate the individual efficiencies of the boilers, engines and auxiliaries. However, the results of a test upon one of the boilers have now become available and, although this was made some time after the complete plant test referred to, it is reasonable to assume that the boiler efficiency had not changed appreciably. In view of this it would appear that the boilers were largely responsible for the very high plant efficiency.—EDITOR.

The object of the tests, the results of which are here shown, was to determine the efficiency, under average operating conditions, of the burners and furnaces. The seven tests covered by this report were all made with Hammel patent furnaces and burners, and it is believed that the results would justify the statement that these trials represent the highest economies ever obtained under similar conditions.

The boiler tested was of the Babcock & Wilcox type, of which there are eighteen in the plant, each containing 6042 square feet of effective heating surface and rated at 604 boiler horsepower. It was designed to carry steam at 200 pounds gage pressure, but is ordinarily operated at 185 pounds.

The superheaters, which were designed to give 100 degrees superheat at the nozzle, are also of the Babcock & Wilcox type, having two loops of tubes in two decks and approximating 960 square feet of superheating surface to each boiler.

There are three passes in the boiler, the products of combustion rising through the first pass, which is baffled along the lower row of tubes from the first flame plate to the bridgewall by fire tile. The gases then pass over and through the superheater to the second pass, and from there to the last pass, from which they escape to the uptake.

The furnace was of the Hammel type, having a separate tunnel for the air supply to each burner. The burners were also of the Hammel patent inside-mixer type, there being three to the furnace. These were arranged under an arch in the bridgewall, and the direction of the flame was toward the furnace front. Fig. 1 shows the arrangement of furnace and

burners; while Fig. 2 is a view of the burner.

The feed water was measured by means of platform scales and tanks, and precautions were taken to detect any leakage.

The fuel oil was pumped from one of the three auxiliary storage tanks, adjacent to the boiler room, at a temperature of 80 degrees Fahrenheit, through a 3-inch quick-acting valve into a weighing tank, from which it flowed through a 4-inch suction pipe to a second pump located near the boiler under test. This pump discharged the oil directly into a Goubert oil heater, where its temperature was increased by the exhaust steam from the pump. From the heater it was discharged to the line leading to the burner. Between the oil pump and the heater there was a bypass which discharged to the reservoir tank. This gave the necessary circulation and allowed a means of pressure regulation.

Samples of the oil were obtained from a tap in the pump discharge between the boiler and the heater. The steam for atomizing purposes was taken from directly under the stop valve of the boiler; consequently, this contained the same degree of superheat as was shown by the thermometer at the boiler nozzle.

For obtaining flue-gas analysis a standard Orsat machine was used. The samples were collected every half hour from the center of the last pass.

The flue temperatures were taken by a Hohmann & Maurer thermometer, reading to 800 degrees Fahrenheit, this being placed between the two dampers at the center of the boiler breeching. Temperatures were taken of the steam at the boiler nozzle; of the oil at the discharge from the heater; of the feed water in the reservoir tank, and of the boiler room at a point about ten feet in front of the boiler and at an elevation above the floor of five feet.

The draft pressure was measured by means of three Ellison differential draft gages, one located at the boiler front, for the ashpit draft, and the other two mounted on the side of the boiler, one being piped to the furnace and the other directly inside the flue dampers. All draft gages were insulated from the boiler setting to prevent error due to heating. The precaution was taken to have the outlets of the draft pipes arranged at right angles to the direction of the flow to prevent inaccuracy due to the velocity. For taking the high temperatures at the different parts of the boiler a Bristol electric pyrometer, reading to 2500 degrees Fahrenheit, was used.

All scales and instruments were calibrated before and after the tests, and were found to be substantially correct.

The blowoff valves on both the boiler and the superheater were disconnected and the water-column outlets were at all times visible for inspection. Also, leakage from the feed-pump glands was collected and returned to the feed-water reservoir.

During all the tests the water level was maintained practically constant at a point four inches from the bottom of the gage glasses. To avoid error due to change of temperatures in the water columns and their connections, the glasses were not blown down at any time immediately prior to or during the tests.

All readings were taken at fifteen-minute intervals during the tests, and every hour the water and oil levels were brought to the same point and calculations made. Besides the power company's testing engineer, there were four men engaged in the tests: one fireman, one temperature reader, one water weigher and one oil weigher. In addition to this crew the company making the burner also had a man in each of these capacities who kept independent log sheets. At the conclusion of each test the logs were compared and they agreed in all cases. Some observations were taken every fifteen minutes, and during none of the trials was anything heavier than a light haze observed; this is particularly true of the maximum-capacity test.

The oil was sampled every fifteen minutes during each run, and, before taking a sample, precaution was taken to see that the sampling pipe was drained. The sample from each test was analyzed twice by the Los Angeles branch of the New York Testing Laboratories and the average results used.

Condition of the Boiler

Before starting the tests it was found necessary to rebuild the division wall

GENERAL DATA AND RESULTS OF TESTS

Test number	1	2	3	4	5	6	7	Average
Duration of test, hours	7	7	7	7	7	7	7	7
Steam pressure, pounds	184.9	184.9	186.0	184.7	183.5	184.6	184.9	184.8
Steam temperature, degrees Fahrenheit	473.3	457.4	468.8	465.1	473.6	493.8	526.7	479.8
Superheat, degrees Fahrenheit	91.8	76.0	86.9	83.7	93.0	112.5	144.3	98.3
Temperature feed water, degrees Fahrenheit	90.5	92.6	92.7	93.4	90.8	94.6	101.2	93.7
Factor of evaporation, pounds	1.237	1.225	1.232	1.229	1.237	1.245	125.9	1.238
Average water level, inches	4	4	4	4	4	4	4	4
Barometer, inches	29.97	30.00	30.00	30.09	30.08	30.04	29.68	29.97
Temperature of boiler room, degrees Fahrenheit	88.7	86.6	84.4	85.2	87.3	86.7	84.4	86.2
Temperature of flue gases, degrees Fahrenheit	385.3	397.5	409.1	406.2	429.0	477.1	537.5	434.5
Draft, in ashpit, inches	0.025	0.035	0.055	0.044	0.071	0.127	0.230	0.084
Draft, in furnace, inches	0.01	0.005	0.025	0.014	0.060	0.130	0.188	0.062
Draft, in rear pass, inches	0.005	0.014	0.061	0.046	0.133	0.296	0.471	0.147
Carbon dioxide, per cent	12.2	13.4	13.3	14.3	14.2	13.3	12.1	13.2
Oxygen, per cent	3.6	2.7	2.4	1.8	1.7	2.8	6.8	3.1
Excess air, per cent	28.7	17.7	18.5	10.6	11.3	18.5	43.0	21.2
Smoke	none	none	none	none	none	none	light haze	
Position of ashpit doors		Do	ors	wid	e	open	through out all tests	
Temperature in first pass above third tube, degrees Fahrenheit	1,100	1,090	1,160	1,180	1,240	1,300	1,600	1,240
Temperature at top of first pass, degrees Fahrenheit	640	640	700	680	780	940	1,170	793
Temperature at top of second pass, degrees Fahrenheit	570	540	620	610	650	740	820	650
Temperature at bottom of second pass, degrees Fahrenheit	500	500	520	510	550	600	700	554
Temperature at bottom of third pass, degrees Fahrenheit	450	450	505	495	530	570	660	523
Total water actually evaporated, pounds	85,766	111,988	129,628	129,609	156,622	191,290	226,558	147,351
Total water evaporated from and at 212 degrees Fahrenheit, pounds	106,092	137,185	159,702	159,289	193,741	238,156	285,236	182,771
Water per hour evaporated from and at 212 degrees Fahrenheit, pounds	15,156	19,598	22,814	22,756	27,677	34,022	40,748	26,110
Steam used by burners, pounds per hour	234	441	549	549	624	708	873	568
Steam used by burners, per cent. of total steam	1.54	2.25	2.40	2.40	2.25	2.08	2.13	2.15
Steam pressure to burners, pounds	48.2	74.7	99.7	102.6	120.4	142.5	167.6	122.2
Oil pressure to burners, pounds	11.4	15.2	24.4	25.4	38.3	46.1	61.6	31.6
Temperature of oil to burner line, degrees Fahrenheit	131.3	134.3	133.5	142.3	140.1	142.1	141.7	137.9
Kind of oil burned			Oil	fro	m Los	Angele	s fields	
Specific gravity of oil at 60 degrees Fahrenheit	0.9770	0.9770	0.9763	0.9770	0.9776	0.9776	0.9797	0.9776
Specific gravity of oil, Baumé, at 60 degrees Fahrenheit	13.3	13.3	13.4	13.3	13.2	13.2	12.9	13.2
Moisture in oil, per cent	0.4	0.5	0.45	0.4	0.8	0.65	0.6	0.54
Heat value of oil as fired, B.t.u.	18,280	18,256	18,131	18,253	18,214	18,171	17,985	18,184
Heat value of oil, corrected, B.t.u.	18,353	18,347	18,212	18,326	18,357	18,289	18,093	18,281
Total oil as fired, pounds	6,913	8,758	10,322	10,115	12,602	16,580	20,205	12,213
Total oil, corrected for moisture, pounds	6,885	8,714	10,276	10,075	12,501	16,472	20,084	12,144
Oil per hour as fired, pounds	987	1,251	1,474	1,445	1,800	2,369	2,887	1,745
Oil per hour, corrected, pounds	983	1,245	1,467	1,439	1,786	2,353	2,869	1,735
Water evaporated from and at 212 degrees Fahrenheit per square foot heating surface, pounds	258	3.24	3.78	3.77	4.58	5.63	6.74	4.32
Boiler horsepower, builders' rating, B.h.p.	604	604	604	604	604	604	604	604
Boiler horsepower developed, B.h.p.	439.3	568.0	661.3	659.6	802.2	986.2	1,181.0	756.8
Per cent. builders' rating	72.7	94.0	109.4	109.2	132.8	163.3	195.5	125.3
Water evaporated per pound of oil from and at 212 degrees Fahrenheit:								
Oil as fired, pounds	15.35	15.66	15.47	15.75	15.37	14.37	14.12	15.15
Corrected for moisture, pounds	15.41	15.74	15.54	15.81	15.49	14.46	14.20	15.23
Boiler efficiency, per cent	81.1	82.8	82.4	83.3	81.5	76.4	75.8	80.47

between the boiler under test and the one forming the other half of the battery. The boiler was cleaned about four days prior to starting the first test, and was in operation two days before the test was begun. The tubes were dusted off through the dusting doors, by means of a steam jet, every morning before starting a test. As the tests were to be, as far as practicable, representative of operating conditions it was considered that this cleaning was sufficient to fulfil the average conditions.

The setting was in extremely poor condition, and it was found advisable to stop up the worst cracks. During the tests there was quite a number of small air leaks in different parts of the setting which did not receive any attention.

Prior to making the tests herein recorded, an inspection was made of the tubes as a result of which four in the first row were replaced. At the conclusion of the tests the tubes were again inspected and they were all found to be in good condition; also, the furnace brickwork was given a careful inspection and there was no apparent injury.

Starting and Stopping Trials

All tests were started and stopped by a whistle signal. The boiler was operated at the load under which it was tested for a period of three to four hours before actual starting, and as the fires were maintained uniform the water level was practically constant at the time of starting and stopping. The water glasses were provided with washers at fixed points, and no trouble was experienced in having the water at these fixed levels at the start and finish. Therefore, it was found unnecessary to make any corrections for difference in levels.

The boiler was at "standby" about four hours every night, but the four-hour period of service before the test was considered sufficient to heat the setting thoroughly and to eliminate the possibility of heat storage.

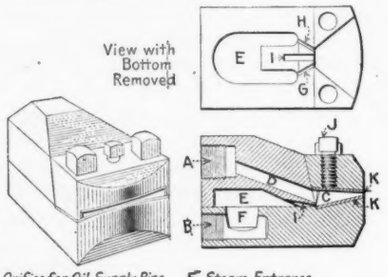


Fig. 2. Hammel Burner

Results Of Tests

Fig. 3 shows graphically the efficiency referred to the boiler horsepower developed, while Fig. 4 shows the efficiency as plotted against the water evaporated from and at 212 degrees Fahrenheit per square foot of heating surface. In both curves it will be noted that the points at 33.6 and 64 per cent. above rating are somewhat below the curve. This is accounted for by the fact that at the point of maximum capacity it was found that the ¼-inch pipe which the makers supplied with the burners was entirely too small for atomizing the oil at the higher loads, and to make the maximum-capacity test ⅜-inch pipe was substituted. This is indicated by the drop in burner efficiency at those points. In order to get the maximum capacity it was also found necessary to increase the width of the tunnels and to provide a greater number of air openings through the grates.

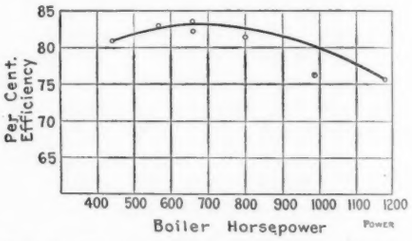


Fig. 3. Efficiencies at Various Horsepowers

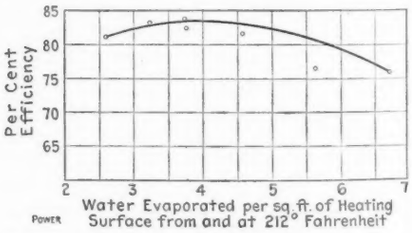


Fig. 4. Efficiency Referred to Evaporation per Square Foot of Heating Surface

It is regretted that the two tests mentioned were not repeated, but lack of time prevented and it is reasonably certain that had additional tests been made it would have shown these points very close to the curve.

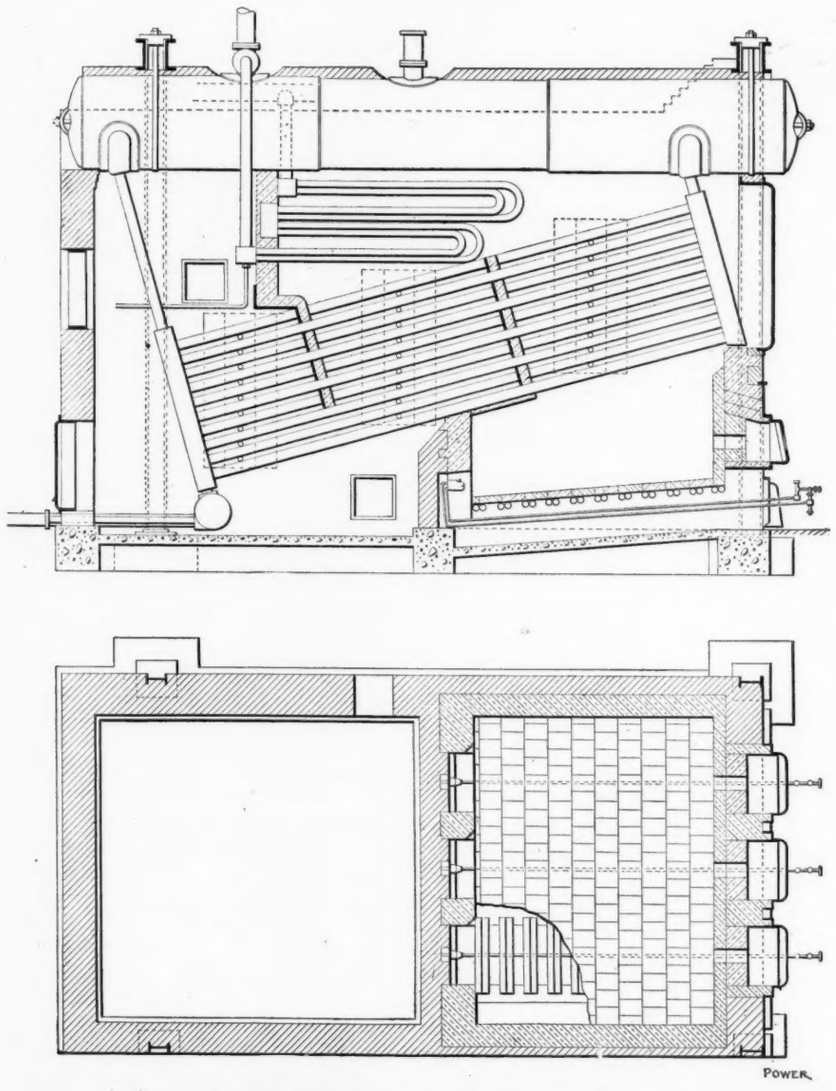


Fig. 1. Boiler Showing Arrangement of Furnace

Fig. 5 shows the efficiencies referred to the pounds of water evaporated per pound of oil, corrected for moisture, and in Fig. 6 is given a curve showing the relation between the percentage of carbon dioxide and the boiler horsepower.

Fig. 7 shows the relation between the boiler horsepower and the water evaporated per square foot of heating surface, from and at 212 degrees Fahrenheit.

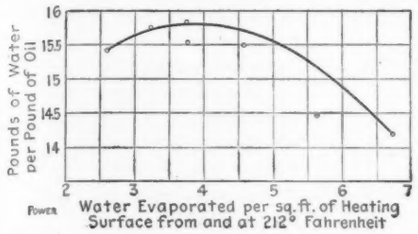


FIG. 5. EVAPORATION PER SQUARE FOOT OF HEATING SURFACE REFERRED TO EVAPORATION PER POUND OF OIL

CALCULATIONS

In calculating the factor of evaporation the specific heat of superheated steam was taken as 0.6 for the gage pressure obtained.

The amount of steam used by the burners was obtained by placing the burner in the water-weighing tank, with the connecting piping and fittings the same as were used during the tests. The average steam pressure for the different tests was then maintained on the burner line for a period of half an hour. The amount of condensation was then weighed and this was checked by figuring the amount of discharge by temperature readings. For additional accuracy several different trials were made at each point, and these all agreed within a very small per cent. In the burner-efficiency calculations there is a small discrepancy between the actual and the test conditions due to the difference between the pressure of the oil and of the water. Under operating conditions the steam in the burner head is retarded in its flow by the pressure due to the oil in the mixing chamber, while the tests made by the tank method gave a greater steam flow due to there being only a very slight water pressure.

It was also found that with heavy boiler loads the tubes directly exposed to the fire suffered much less than with the light loads. This is accounted for by the fact that on the heavy loads the distribution of heat throughout the boiler was much more uniform than with the light loads, which had a tendency to concentrate the heat in the front part of the boiler, due to the difference of draft.

CONCLUSIONS

In order to demonstrate what advantage a long furnace would have over a short one, a furnace was installed having a total length of eight feet, which was two feet shorter than the one installed by the boiler company at the time the boiler was erected. A test demonstrated clearly that far better results could be obtained with the long furnace, having a length of ten feet from the face of the bridgewall to the inside face of the boiler front, and it was at this point that the first six tests were made.

To obtain the maximum capacity it was found necessary to increase the width of the tunnels to give a slower air velocity through the grates, and to increase the number of openings through the grate. At that time the bridgewall was also moved back another six inches, which increased the cubical contents of the firebox about 19 cubic feet, and greatly assisted the combustion at high loads. It is also believed that the large firebox would greatly assist the combustion at the lower evaporative points. In all cases it was found that the best results were obtained by leaving the front dampers wide open, and controlling the admission of air entirely by the rear damper. By this means the velocity of the gases was kept at a minimum, which seems to be essential for the best combustion.

In several instances during preliminary trials the temperature of the oil in the reservoir tank was increased to 120 degrees Fahrenheit, and it was found that by so doing the efficiency of the boiler dropped considerably. This would indicate that for average conditions it is a great mistake to heat the oil to excessive temperatures, except in cases where it is absolutely essential for handling. During the tests, with oil having a specific gravity of about 13, the temperature was maintained at 80 degrees Fahrenheit, which temperature gave the most satisfactory results. The excessive heating of the oil causes decomposition of the hydrocarbons.

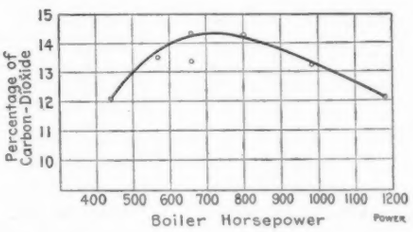


FIG. 6. RELATION BETWEEN CO_2 AND HORSEPOWER

It is believed that the efficiencies of all tests would have been materially improved had it been possible to obtain a steady oil pressure on the burners. The pump was not supplied with any sort of automatic-control device, and as a result it was impossible to keep the pressure from varying from five to fifteen pounds.

It was found that the better known burners could be divided into three classes: those using excessive amounts of steam for atomizing—over 3 per cent. of the total steam generated; those whose steam consumption is less than 1½ per cent., and the ones whose steam consumption lies between the two. In the first case the different pipes and burner openings are of large area and offer small resistance to the passage of dirt, with the result that these burners do not become obstructed and can be operated at a very low maintenance cost. This, however, is offset by the excessive steam used. In the second case the passages must be extremely small and the burner consequently becomes obstructed very readily, resulting in excessive maintenance costs, which more than equal the steam economy. It is obvious, therefore, that a burner fulfilling the requirements between the two extremes is best adapted for general use.

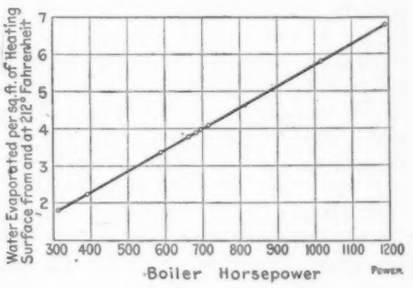


FIG. 7. RELATION BETWEEN HORSEPOWER AND EVAPORATION

It is to be regretted that sufficient data was not obtained from the analysis of the oil samples to permit the working up of a "heat balance," but it is believed that the information given will otherwise be found complete.

An Expert and a Strap Brake

"Yes," said Jones, "our superintendent at the Throwemtogether Engine Works was the engine man for you. He wouldn't let any engine out of the shops without taking cards running free and with all she could pull. You should have seen the slick rig he got up to load them. He fixed up a long wooden beam with a piece of belting and bolts (strap brake). Well, of course, he didn't get onto this rig first shot. Instead of letting the arm shove against the floor, he started in with it on the other side and had enough of the lads sit on it to hold it down. Anyway, this worked fine until one time the brake seized, and threw a bunch of the men over the engine. Of course, not even the smartest engine men can get these fancy stunts perfect first time."

An employee in a sawmill near Duluth, Minn., was killed in a peculiar manner. One of the balls of a steam-engine governor flew off and struck him on the head, causing instant death.

The Cooling of Circulating Water

By Edward F. Miller

A method of calculating the volume of air required to cool a given amount of circulating water passing through a cooling tower, and calculations showing that under certain conditions it is better to employ a moderate vacuum than a high one where a cooling tower is used.

*From a paper presented at the Congress of Technology, at Boston, April 11, 1911.

Whenever possible, large power plants are located near a river or near tide water, in order to obtain an abundant supply of condensing water; in many cases, however, plants have to be located where there is either no supply or but a limited supply of water which can be used for condensing purposes. In such cases if the plant is to be run condensing, it becomes necessary to cool the condensing water after it has passed through the condensers so that it may be used over and over again. Some of the various devices for cooling the water are: Cooling towers, spray nozzles, cooling ponds, and spray nozzles combined with cooling ponds.

In every case, with the exception of the "cooling ponds," the greater part of the cooling is effected through the evaporation of a small part of the water circulated, each pound of water evaporated taking approximately one thousand heat units from the water left. This method of cooling by the rapid evaporation of a part of the liquid was known and made use of in India 2000 years ago.

According to Dalton's law, the weight of steam required to fill a certain volume at a given temperature is the same regardless of whether any air is present. The resulting pressure is the sum of the pressure exerted by the air and that exerted by the steam, considering that each occupied the same volume separately. The weight of moisture required to saturate one cubic foot of dry air, or that which will occupy one cubic foot, can be calculated from any reliable tables giving the properties of saturated steam.

The curved line (Fig. 1) was computed by taking from the steam tables values representing the reciprocal of the volumes of one pound of steam at the different temperatures. From this it is evident that at 66 degrees, 0.0010 pound is required to saturate a cubic foot of dry air and at 130 degrees, 0.0063 pound is required. If air at 66 degrees were 70 per cent. saturated, or had a relative humidity of 70, then the amount of moisture in a cubic foot of such air would be

$$0.7 \times 0.001 = 0.0007 \textit{ pound}$$

and if the air were saturated at 130 degrees the additional amount taken up would be

$$0.0063 - 0.0007 = 0.0056 \textit{ pound}$$

Cooling Towers

Probably cooling towers are used to a greater extent for cooling water than spray nozzles or cooling ponds, although spray nozzles are coming into frequent use now that engineers know more about them.

The amount of water surface in a cooling tower varies from 23 to 27 square feet per indicated horsepower, more surface being needed in a natural-draft tower than in a fan tower. The amount of air required depends to a large extent upon the humidity of the air entering the tower and upon the temperature of the water entering the tower. The air leaving the tower is usually saturated. It is not advisable to send an abnormal

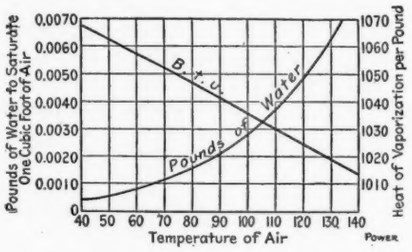


FIG. 1. WATER REQUIRED TO SATURATE AIR AND HEAT OF VAPORIZATION

amount of air through a tower as the cost of the increased power required to run the fan and the greater shrinkage in the bulk of water due to evaporation may amount to more than the gain made by the increased vacuum on the engine.

The materials used inside of cooling towers for bringing as large a surface of cooling water as possible into contact with the air, without obstructing the free flow of air, are tiers of tile paper, galvanized-iron wire screens set nearly vertical, galvanized-iron troughs set horizontally and arranged so that the water flows from trough to trough as it descends, boards, brush or other material.

The amount of air to be supplied to a tower and the shrinkage of water due to evaporation, may be calculated with sufficient accuracy from the following equations:

$$W(Q_h - Q_c) = \frac{V_c}{0.736\,\frac{T_c}{P_c}} \times 0.24\,(T_h - T_c) + r\left(\frac{V_h}{\text{Specific volume of steam at the temperature of the air at top}} - \frac{V_c}{\text{Specific volume of steam at the temperature of the air at bottom}} \times \textit{relative humidity}\right)$$

where,

W = Weight of cooling water entering the condenser per pound of steam;

V_c = Cubic feet of cold air entering the tower per pound of steam condensed. This air may enter by natural draft or be forced in by a fan;

V_h = Absolute temperature of air leaving the tower; condensed and is equal to $\frac{V_c T_h}{T_c}$;

T_c = Absolute temperature of entering air;

T_h = Absolute temperature of air leaving the tower;

P_c = Absolute pressure of air entering the tower in inches of mercury;

Q_h = Heat contained in hot condensing water;

Q_c = Heat contained in cold condensing water;

r = Heat of evaporation corresponding to temperature at top of tower.

The first factor,

$$\frac{V_c}{0.736\,\frac{T_c}{P_c}} \times 0.24\,(T_h - T_c)$$

represents the heat given up directly to the air and the second part of the equation

$$r\left(\frac{V_h}{\text{Specific volume of steam at the temperature of the air at top}} - \frac{V_c}{\text{Specific volume of steam at the temperature of the air at bottom}} \times \textit{relative humidity}\right)$$

represents the heat given up by evaporation of some of the water. This expression divided by r represents the weight of water evaporated from the pond per pound of steam condensed; represent this by E.

If E is greater than one pound the excess must be supplied by makeup water. For a surface condenser E represents the makeup water.

If the excess pressure of the air entering the tower is measured by the difference of water level in a U-tube, P_c will equal the sum of the barometric reading and $\frac{0.0365}{0.491}$ times the difference in water level.

In nearly every case P_c varies so little from the reading of the barometer that the barometric hight in inches of mercury may be substituted for it.

Example:

A cooling tower receives water from a surface condenser at 122 degrees Fahren-

heit; the water leaves the cooling tower at 90 degrees Fahrenheit; temperature of outside air 72 degrees, relative humidity 80 per cent.; temperature of condensed steam 95 degrees; vacuum in condenser 25 inches; barometer 29.7 inches. Engine of 500 horsepower and consumes 20 pounds of steam per horsepower-hour.

Find the amount of air needed per pound of steam condensed and the per cent. loss of cooling water due to evaporation.

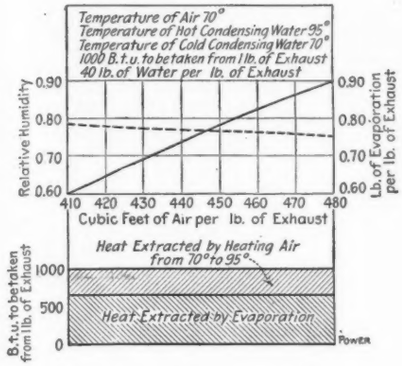

Temperature of Air 70°
Temperature of Hot Condensing Water 95°
Temperature of Cold Condensing Water 70°
1000 B.t.u. to be taken from 1 lb. of Exhaust
40 lb. of Water per lb. of Exhaust
Relative Humidity
0.90
0.80
0.70
0.60
Lb. of Evaporation per lb. of Exhaust
410 420 430 440 450 460 470 480
Cubic Feet of Air per lb. of Exhaust
Heat Extracted by Heating Air from 70° to 95°
Heat Extracted by Evaporation
B.t.u. to be taken from 1 lb. of Exhaust
1000
500
0
Power

FIG. 2. CONDITIONS WITH 28-INCH VACUUM

$$W = \frac{1053.2 - 63.1}{90.0 - 58.1} = \frac{990.1}{31.9} = 31.8$$

Substituting in the foregoing formula

$$31.8(90-58.1) = \frac{V_c}{\frac{0.736 \times 531.5}{29.7}} \times 0.24(50)$$

$$+ 1023.2\left(\frac{V_c\ 581.5}{531.5 \times 192.7} - \frac{V_c}{813} \times 0.80\right)$$

$$990.1 = 0.902\ V_c + 1023.2$$

$$(0.00568\ V_c - 0.00098\ V_c) = 0.902\ V_c + 4.809\ V_c$$

whence

$$V_c = 173 \text{ cubic feet}$$

$$E = (0.00568 - 0.00098)\ V_c = 0.815$$

$$\frac{0.815}{31.8} = 0.0256 \text{ or } 2.56 \text{ per cent.}$$

To illustrate more fully the use of the equation and to illustrate also the extra cost (at the cooling tower) of a high vacuum over a moderate vacuum two cases will be considered:

First: A condenser maintaining a 28-inch vacuum with hot condensing water at 95 degrees Fahrenheit, or 7 degrees below the temperature corresponding to the vacuum; cold condensing water at 70 degrees Fahrenheit, and exhaust steam containing 4 per cent. moisture. Forty pounds of circulating water are figured as the minimum needed to abstract the heat from a pound of the exhaust steam. Calling the relative humidity 90 per cent. and applying the foregoing formula:

$$40(95-70) = \frac{V_c}{0.736\frac{529.5}{29.92}} \times 0.24\ (95 - 70)$$

$$+ 1038.5\left(\frac{V_c\ 554.5}{404.8 \times 529.5} - \frac{V_c}{868} \times 0.90\right)$$

$$1000 = 2.077\ V_c$$

whence,

$$V_c = 431 \text{ cubic feet}$$

The evaporation from the tower per pound of steam condensed in the condenser is 0.748 pound and

$$1038.5 \times 0.748 = 776.8 \text{ heat units}$$

carried off by the water evaporated; the balance, 223.2 B.t.u., is taken up in heating the air.

With 80 per cent. humidity, 455 cubic feet of air would be needed and 0.761 pound would be evaporated. Similar calculations for 70 and 60 per cent. of humidity give, respectively, 430.9 cubic feet of air and 0.772 pound of water evaporated and 410.7 cubic feet of air and 0.781 pound of water evaporated.

Second: Suppose that the vaccum to be carried is 26 inches with air at 70 degrees and hot condensing water at 119 degrees, or 7 degrees below the temperature corresponding to the vacuum. Cold water at 70 degrees and 4 per cent. moisture in the exhaust steam. The heat to be abstracted per pound of exhaust is 983 B.t.u. and 20.6 pounds of cooling water is the minimum required per pound of exhaust.

From calculations similar to the preceding it appears that the amounts of air needed and the evaporations are as follows:

Relative Humidity	Cubic Feet Air	Evaporation in Pounds
90	188.4	0.793
80	184.3	0.797
70	180.0	0.800
60	176.5	0.804

The amount of water evaporated per pound of steam condensed is about the same in each case.

In the first case the evaporation averaged 0.77 pound in 40 pounds of water sent into the tower, or 1.92 per cent.; in the second case about 0.80 pound in 21 pounds of water, or 3.81 per cent.

The results of the calculations are plotted in Figs. 2 and 3. It is evident from these that the amount of heat taken up in the heating of the air was about the same for any one case, regardless of the humidity.

PERCENTAGE OF ENGINE POWER REQUIRED BY COOLING-TOWER FAN AND BY THE EXTRA DISCHARGE HEAD ON THE CIRCULATING WATER DUE TO THE TOWER

Referring to the first case cited, with a relative humidity of eighty, 455 cubic feet of air were found to be needed. Suppose a disk fan is to be used and a dynamic head of 0.3 inch of water maintained at the fan. As the static head is zero the velocity head will be 0.3 inch. This corresponds at 70 degrees to a velocity of 2200 feet per minute. Suppose that the main engine uses 14 pounds of steam per horsepower per hour, then the steam per minute is $14 \div 60$ and the cubic feet of air sent through the tower per pound of steam is $\frac{14}{60} \times 455$.

The horsepower input to the fan is, for this case, if 30 per cent. is assumed as the fan efficiency:

$$\text{Horsepower} = \frac{0.3 \times 5.2 \times \frac{14}{60} \times 455}{33{,}000 \times 0.30} =$$

0.0167, *or* 1.67 *per cent.*

of the engine power.

To this should be added the power due to pumping $\frac{14 \times 40}{60}$ pounds of cooling water per minute through an additional head of about 30 feet. This amounts to 0.00848 horsepower.

If the fan were driven by a small engine using 35 pounds of steam per horsepower-hour and the circulating apparatus were also steam driven, using 40 pounds per horsepower-hour, then the extra steam required by the cooling-tower outfit would be

$$0.0167 \times 35 + 0.00848 \times 40 = 0.923$$

and

$$\frac{0.923}{14} = 0.066, \text{ or } 6.6 \text{ per cent. additional}$$

A similar calculation for the second case with a 26-inch vacuum and 80 per cent. humidity, with the engine using 15 pounds of steam per horsepower-hour, gives:

Air per minute =

$$\frac{15}{60} \times 184$$

Horsepower to fan =

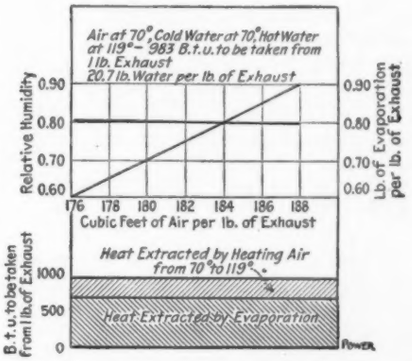

Air at 70°, Cold Water at 70°, Hot Water at 119° — 983 B.t.u. to be taken from 1 lb. Exhaust
20.7 lb. Water per lb. of Exhaust
Relative Humidity
0.90
0.80
0.70
0.60
Lb. of Evaporation per lb. of Exhaust
176 178 180 182 184 186 188
Cubic Feet of Air per lb. of Exhaust
Heat Extracted by Heating Air from 70° to 119°
Heat Extracted by Evaporation
B.t.u. to be taken from 1 lb. of Exhaust
1000
500
0
Power

FIG. 3. CONDITIONS WITH 28-INCH VACUUM

$$\frac{0.3 \times 5.2 \times \frac{15}{60} \times 184}{33{,}000 \times 0.30} = 0.00725$$

The additional horsepower on the circulating pump =

$$\frac{20.6 \times \frac{15}{60} \times 30}{33{,}000} = 0.00468$$

If the fan engine and the circulating apparatus were steam driven, then using the same rate as before:

$$0.0072 \times 35 + 0.00468 = 0.442$$

and

$$\frac{0.442}{15} = 0.0295, \text{ or about } 3 \text{ per cent. additional}$$

If the cooling surface used in the tower offers much resistance to the free discharge of air from the fan through the tower, it may be necessary to run the fan at a higher velocity and this increases the work of driving.

Spray Nozzles

By spraying water into the air, cooling may be effected through the evaporation of a part of the water just as in the case of the cooling tower. The total exposed surface of the sprayed jet meets less air per pound than in the cooling tower, and on this account it is often advisable to spray 30 to 50 per cent. of the water a second time before sending it through the condenser.

Generally speaking, spray nozzles of the size known as 2 inches are the most economical. This size screws onto a 2-inch outlet, the opening in the nozzle tip being about 0.8 inch. As many nozzles should be provided as are needed to discharge the entire weight of condensing water under a pressure of not over 15 pounds gage at the nozzle.

The nozzles should be set from 8 to 10 feet apart if 2 inches; and a greater distance if over 2 inches. Where a number of nozzles are used, it is customary to have the water which is sprayed into the air fall back into an artificial pond one or two feet deep. Also, when a number of nozzles are in use the aspirator effect produced by the jets causes a current of air to flow along the surface of the pond from the edge toward the center and this current of air assists to some extent in the cooling.

In some few instances spray nozzles have been put along the edges of a narrow brook and the falling spray caught on board fences inclined 30 degrees with the ground and draining into the brook.

There are a few small plants where the cooling nozzles discharge onto the roof of the building. The extra head of water on the circulating pump makes this inadvisable, however.

Experiments on Schutte & Köerting nozzles of sizes known as 3, 2 and 1 inches have been carried on at the Massachusetts Institute of Technology since 1908; and at the present time two other types of nozzle are being tested. The nozzle under test is placed at the center of a flat roof about 44x40 feet, sloping 1 foot in 10 feet, and the water caught on the roof is drained into tanks and weighed. The discharge through the nozzle is figured from the pressure shown by a gage attached to a piezometer just beneath the nozzle, the coefficient for each nozzle having been determined by exhaustive tests made in the laboratory. From the tests on the Schutte & Köerting nozzles the following seem to hold true:

1. The temperature of the water after spraying is more dependent upon the temperature and humidity of the atmosphere and upon the fineness of the spray than upon the initial temperature of the water. Therefore, it is advisable to spray the water as hot as possible without excessive steaming.

2. At high humidities, say 80 or 90 per cent., the temperature of the water may be lowered to within 12 or 13 degrees Fahrenheit of the temperature of the air, with a total drop in temperature of 35 to 40 degrees Fahrenheit.

3. At low humidities, of 20 to 30 per cent., the temperature of the water after spraying may be as much as 8 degrees below the temperature of the air and the total drop in temperature 40 to 45 degrees Fahrenheit.

4. The loss of water by evaporation is approximately 0.15 pound per degree lowering of temperature per 100 pounds of water discharged, or a gross loss of about 6 per cent. for 40 degrees Fahrenheit lowering of temperature. In no case was the loss found to exceed 7 per cent.

The discharge from these nozzles was found to be as shown in the following:

DISCHARGE FROM NOZZLES UNDER TEST

Head in Feet at Base of Nozzle	Cubic Feet per Minute for 1-Inch Pipe. Diameter of Nozzle at Tip = 0.406 Inch	Cubic Feet per Minute for 2-inch Pipe. Diameter of Tip = 0.800 Inch	Cubic Feet per Minute for 3-inch Pipe. Diameter of Tip = 1.181 Inches
25	1.782	6.736	14.83
30	1.952	7.379	16.24
35	2.109	7.971	17.54
40	2.254	8.521	18.75
45	2.391	9.036	19.89
50	2.520	9.526	20.97
55	2.643	9.991	21.99
60	2.761	10.44	22.97
65	2.873	10.86	23.91

Cooling Ponds and Spray Nozzles

When there is a natural pond of moderate size adjacent to a power plant, sufficient cooling may be obtained by spraying all or a part of the condenser discharge, the cooling from the surface of the pond being of considerable assistance.

Cooling Ponds

Unless the pond is of considerable area the cooling from mere surface contact with the air is not usually sufficient to keep the temperature from rising, especially on hot damp days.

Bonom Steam Turbine

A brief description of a new development of the radial-flow turbine, showing the steps taken to secure a maximum number of expansions in a machine of comparatively small diameter and short length.

In the development of the steam turbine which has been more rapid than that of any other prime mover a great diversity of types has been evolved. In the axial flow in order to get the largest possible number of expansions it has been necessary to use designs involving rotors of either comparatively great length or of large diameter. In the radial flow the diameters have been large, and of comparatively low rotative speed. The Bonom turbine is a radial-flow machine of comparatively small diameter and short length and consequently capable of a high degree of rotative speed or of containing within a small space the number of stages necessary for efficiency at low speeds.

If the long rotor and case of an axial-flow turbine could be compressed accordion fashion into a series of rings of uniform diameter with deep recesses between, and with buckets or blades on the sides of the rings running between the redirecting buckets of the case it would in a way illustrate the Bonom idea of turbine construction.

The idea of the turbine is shown in the longitudinal and cross-sections, Figs. 1 and 2, the latter consisting of eight partial sections through the correspondingly numbered planes of Fig. 1.

At the left of the casing is the inlet chamber or steam chest extending entirely around the case furnishing steam to the ring of nozzles, which are opened and closed by a perforated ring valve under the control of the governor.

These nozzles are of the convergent-divergent type designed for a considerable initial fall of pressure with the production of a high jet velocity. They are shown in the section *I—I* of Fig. 2 which shows also the three rows of blades, the middle one stationary and the two others moving, through which this velocity is abstracted. The initial stage is thus of the double-velocity or Curtis type, expanding the steam to such a volume that even with full admission, that is, with steam admitted through the full circumference, the first blades may be of considerable size. This reduces the proportion of clearance to blade area, and the low pressure attained by expansion in the symmetrical nozzles reduces the tendency to leak by the blades in the later stages.

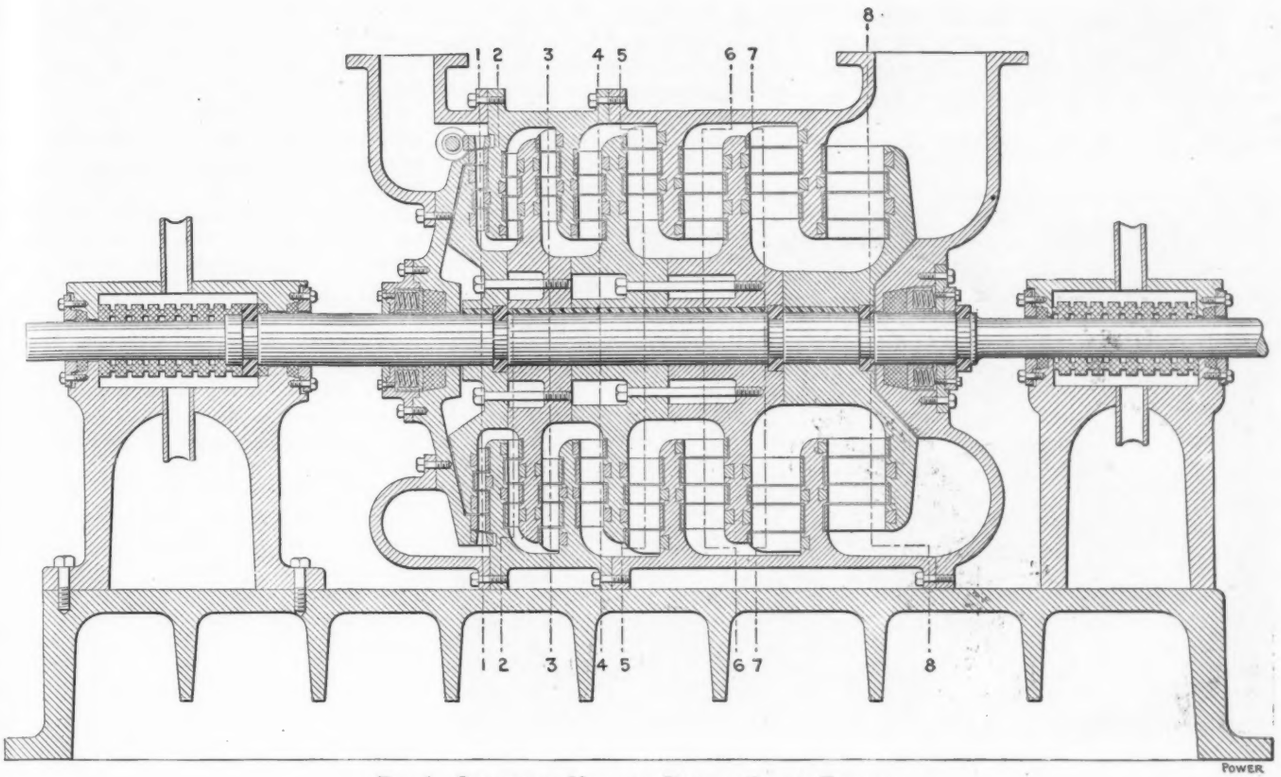


FIG. 1. SECTIONAL VIEW OF BONOM STEAM TURBINE

After the first stage the type becomes that of Parsons with continuous expansion through the constantly increasing passages of alternately rotating and fixed rows of blades. The peripheral velocity of the blades would be different, according as they were nearer to or farther from the shaft; but if the design favors those having the mean velocity it is suggested that a change in speed will improve the efficiency of those to one side of this line while diminishing that of those upon the other and thus permit a considerable change in speed with small variation in torque or efficiency.

Both the moving and stationary vanes are secured in dovetail grooves and are provided at the outer ends with lips which connect one to the next and form a complete shroud which except for the necessary mechanical clearance closely fits an annular groove at the opposite side of the chamber, making a smooth continuous path for the steam and preventing the es-

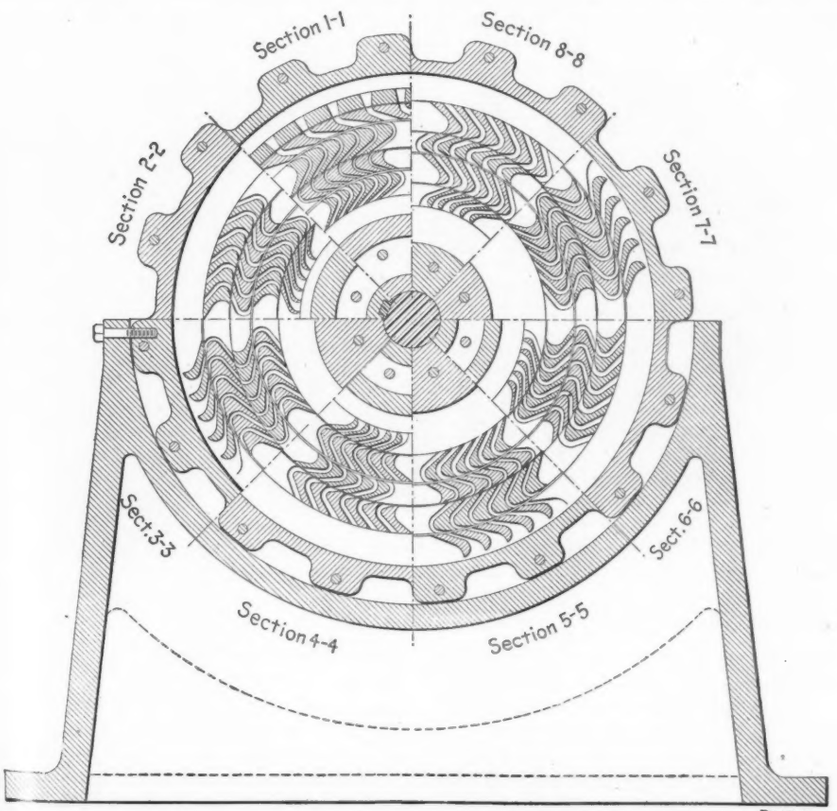


FIG. 2. PARTIAL CROSS-SECTIONS THROUGH LINES 1-1 TO 8-8

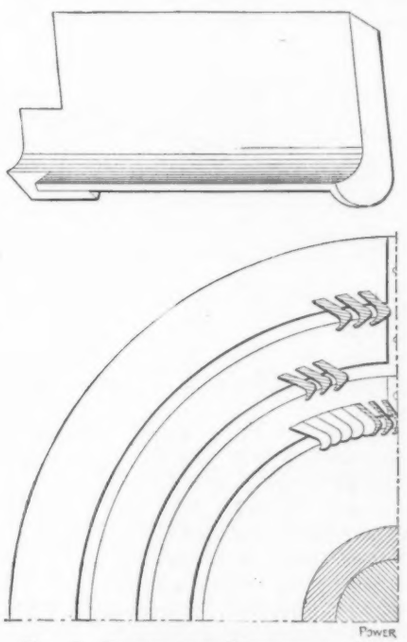


FIG. 3. BLADE AND METHOD OF ATTACHMENT

cape of steam around and over the ends. This is clearly seen in Fig. 1, while Fig. 3 shows the form of the buckets and their arrangement, both in the stationary and moving parts.

Fig. 4 shows the disassembled stator

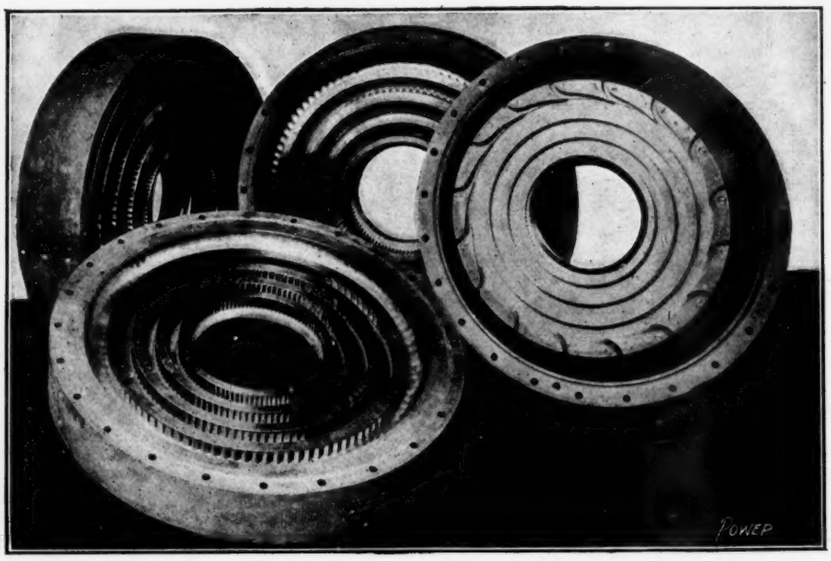


FIG. 4. DISASSEMBLED STATOR SECTIONS

rings, and Fig. 5 the rotor rings reassembled on the shaft, giving a clear presentation of the progressive increase in the volume provided for the expansion of the steam as it gives up its energy in passing through the successive stages. In the stator ring at the right in Fig. 4 the first set of directing nozzles is plainly shown. Around the outside of this circle of nozzles there is another ring with perforations corresponding to the entrance openings of the nozzle which under the control of the governor is advanced or retrograded as the load de-

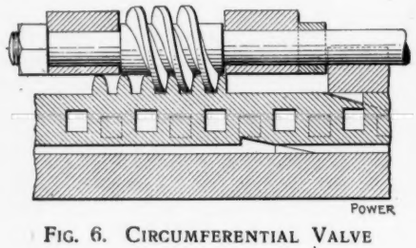


FIG. 6. CIRCUMFERENTIAL VALVE

mands, throttling the steam for light loads or giving a wide opening for heavy ones.

Fig. 6 is a short section, showing the construction and method of operating this admission ring which may be called the circumferential valve. This valve is moved circumferentially by the worm and is also guided in a sidewise direction by angle blocks which cause the openings through the valve to approach and pass over the entrance openings of the nozzle diagonally until full opening is obtained when the valve reaches full travel.

The drawings submitted do not show any provision for balancing the end thrust resulting from the differences of pressure on opposite sides of the rotating disks. This may be done by the use of a dummy piston which may be small on account of the absence of high-pressure steam in the bladed portion of the case; by reversing the flow and making the pressure act toward the nozzles in the later stages, or by splitting the turbine into a double-flow, a procedure favored by the original acceptance of the initial-velocity stage.

It is intended to build these machines in convenient commercial sizes for all classes of work.

The inventor is Alfred Bonom and the turbine is handled by the Bonom Turbine Company, Central Bldg., Paterson, N. J.

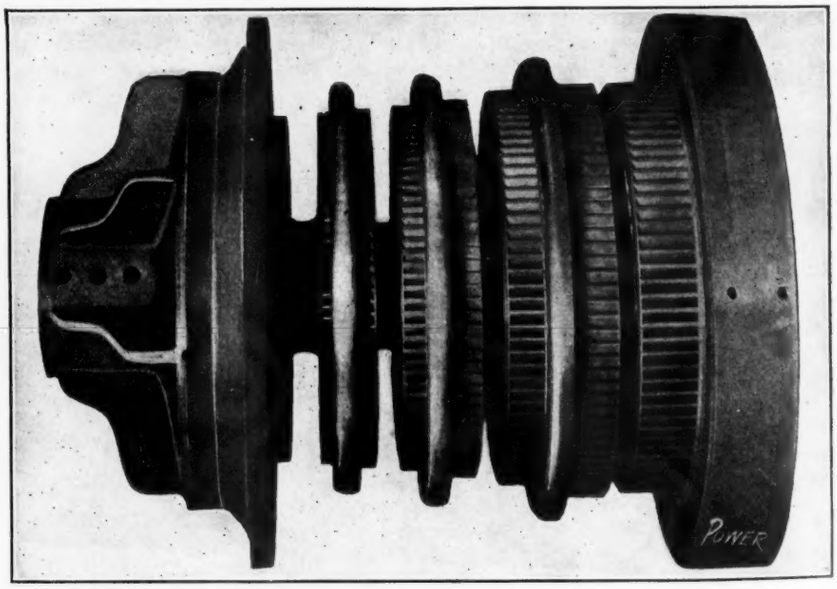


FIG. 5. ROTOR SHOWING PROGRESSIVE INCREASE IN WIDTH OF BLADES

The Value of the CO_2 Recorder

BY H. S. VASSAR

In a recent issue of POWER there appeared a letter headed, "Economy in the Boiler Room," which called attention to the need of boiler-room records, especially in the case of electric-power plants. The article was a timely one, bringing out many points which certainly require watching if economies are sought.

I noticed, however, that more stress was laid on flue-gas analysis than on daily coal and water records. Personally, I am inclined to the opinion that without the latter, CO_2 records are of little use. Now, I have no quarrel with those who have so ingeniously devised automatic devices for flue-gas analysis as I fully believe that such instruments have a proper place in many boiler rooms. There are, though, other plants in which CO_2 apparatus has been installed with no facilities for daily coal and water weighing.

Such a condition reminds me of a hungry man who, neglecting the more substantial viands on the table, attempts to satisfy his appetite with pudding or pie. CO_2 enthusiasts often assume that a knowledge of the percentage of CO_2 carries with it something definite concerning the amount of air. While this is true of *excess* air it is not true of the converse, that is, CO_2 records tell nothing about an *insufficient* air supply, resulting in the formation of CO. Unfortunately, high CO_2 is frequently accompanied by a greater or less percentage of CO, the loss due to which sometimes more than offsets the gain due to the low excess-air volume indicated by the high CO_2. Therefore, while high efficiencies cannot be expected with low

CO_2 it does not necessarily follow that high CO_2 is accompanied by economical combustion. In other words, the indications of the automatic CO_2 machines appear to me to be largely negative.

After several years' experience with flue-gas analysis and boiler testing, I do not believe that CO_2 records are at all dependable as measures of furnace efficiency. In support of this contention Figs. 1 and 2 are submitted. These charts

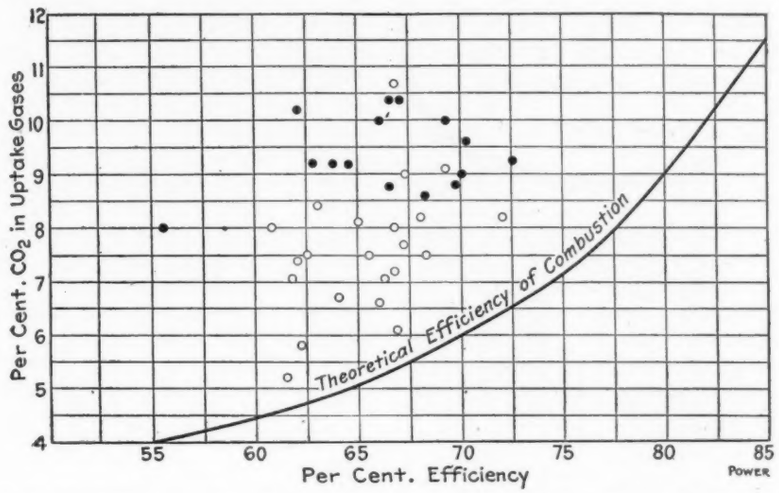


FIG. 1. COMPARISON OF CO_2 PERCENTAGE IN UPTAKE GASES AND EFFICIENCY OF COMBUSTION

were made to establish, if possible, some relation between the percentage of CO_2 in the gases of combustion and the combined boiler and furnace efficiency. They show the results of two series of 8-hour tests on Babcock & Wilcox boilers equipped with mechanical stokers of the inclined type. The tests of the first series, indicated by the black points, were all made on the same boiler and with the same fuel but with various changes in the grate equipment, draft, air admission, etc. In the tests of the second series, indicated by the open circles, several different fuels were burned. All of the coals used were Pennsylvania semi-bituminous.

The CO_2 figures are from continuous samples taken throughout the various tests. In Fig. 1 the samples were from the uptake while in Fig. 2 they were from the top of the first pass. The points at which the samples were collected and the apparatus used were the same in all cases.

The curves showing the theoretical efficiency of combustion were plotted from data given by several different manufacturers of CO_2 instruments and are supposed to show the efficiency of combustion as indicated by the CO_2 content of the flue gases.

I have also used other sets of test figures in the attempt to prove the value of CO_2 records, but with no better results than in the case given.

A word also relative to the paying of bonuses to firemen, based on their CO_2 records, may not be amiss. Two firemen handling boilers side by side may secure results something as follows: "A" burns 2000 pounds of coal in a given hour under his boiler with a CO_2 record of, say, 7 per cent. "B," who fires the adjoining boiler, may burn only half that amount of coal with correspondingly small steam output, but his CO_2 record may be 12 per cent. In other words, "A" does the work and "B" gets the glory and the cash. I do not say that such methods are followed, as, in plants where the system is in use, the supervision is such as to preclude tricks of this kind but, if it lies within the power of the individual fireman to alter his conditions of draft or air supply, such a thing could be easily brought about.

Some of those who have studied the matter of boiler-room management maintain that the chief value of CO_2 recorders lies in the increased attention which is given to the boiler room rather than in the records obtained. In these days, when we hear CO_2 recorders talked of on every side, perhaps some are a little timid about questioning their value. It reminds me of a fairy tale, read during my boyhood. The story ran somewhat as follows:

Two strangers, pleasing in appearance and glib of tongue, appeared one day in the court of a certain king, announcing that they were the sole manufacturers of a most beautiful fabric for royal robes. Indeed, its texture was so wonderfully fine that it was rendered invisible to all save the very wisest of men. Samples were displayed to the king who, at a fabulous price, ordered a robe of the material. For days and days weavers worked at their looms weaving airy nothings from nothing. At last, the great day came when the king was to appear before his people arrayed in the wonderful robe which only the "wise ones" could see. Loud were the exclamations of admiration from his awe-struck subjects.

But, at last, a little child who had not yet become as worldly wise as his elders piped out, "But the king hasn't any clothes on at all."

Once more I would not be understood as condemning all gas analysis nor would I "damn with faint praise," but from experience and observation thus far I believe that there are other practical aids to economical operation which should be in every boiler room before the CO_2 recorder. An Orsat or other type of hand apparatus for gas analysis can be purchased for one-tenth part of the cost of a recorder and will often accomplish just as much.

I have not, thus far, even mentioned the difficulties involved in keeping a recorder in condition for use. Some of those who now have recorders in operation could doubtless write a volume on that subject.

Perhaps this will "start something."

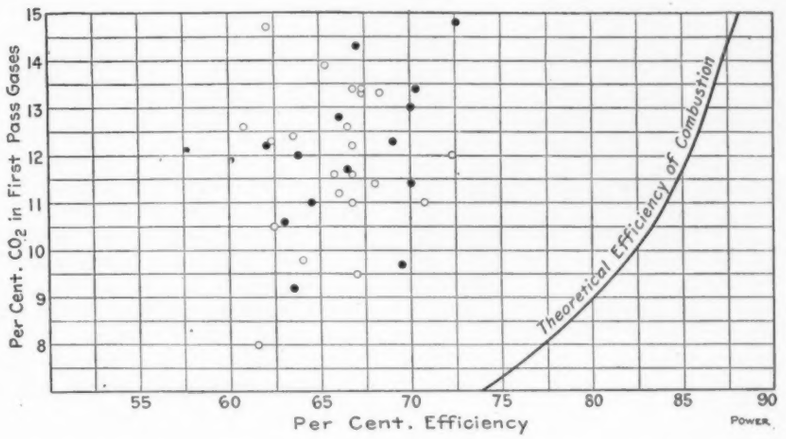


FIG. 2. COMPARISON OF CO_2 PERCENTAGE IN FIRST-PASS GASES AND EFFICIENCY OF COMBUSTION

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

The Care and Operation of Storage Batteries

By Norman G. Meade

An electric storage battery is a combination of cells, each of which is a unit. In the ordinary type a cell is made up of three parts: the jar, the plates and the electrolyte. The jar may be of any good nonconducting and acid-proof material of sufficient strength and rigidity to support the plates and the electrolyte. In the smaller stationary types the jar is generally made of glass or hard rubber. Large cells for central-station work have containing tanks made of heavy planks well joined and lined with sheet lead.

The plates are of two kinds, termed positive and negative, placed alternately, and the number of negative plates is always one more than the number of positives. The group of plates contained in one jar or tank is commonly known as an "element." All of the positive plates in one jar are connected together and all of the negative plates are similarly connected, but the positive plates are separated from the negative plates by insulating strips.

Storage batteries of the ordinary lead-sulphuric acid type are divided into two general types: the Planté and the Faure. Both consist of lead elements in dilute sulphuric acid but the plates are prepared differently. The Planté type of plate is constructed of solid sheet lead so fashioned as to present a large surface area to the action of the electrolyte; the active material is formed on the plates, either electrically, by charging and discharging, commonly called forming, or chemically.

In the Faure type the active material is applied mechanically to lead conducting plates or grids; for this reason the Faure battery is commonly called the "pasted" type. The active material may be in active condition when applied or it may be in such condition that it must be converted into active material by electrical or chemical formation. The positive plate is made of lead upon which a coating of peroxide of lead has been formed or mechanically applied. The negative plate is made of pure lead with a very spongy or porous surface. The peroxide and spongy lead are the portions of the plates which are subjected to chemical action and therefore constitute the active material; the plain lead body of each plate serves as a support for the active material.

The chemical condition of the plates and electrolyte changes when the cell is charged and discharged. At full charge the positive plates have a rich dark-brown coating of peroxide of lead, and the negative plates are a dark slate color. In this condition an electromotive force is set up in the cell, and if the positive and negative terminals be connected through an external circuit, a current will flow through that circuit from the positive to the negative terminals of the cell. When discharged, the positive plates are of a reddish brown or chocolate color and the negative plates a light slate color.

During discharge, the active materials are partly converted to lead sulphate at the expense of some of the acid of the electrolyte, so that the latter becomes weaker. The strength of the electrolyte at any time, compared with its strength when the cell is fully charged, is an approximate indication of the extent of the discharge. The specific gravity should not be more than 1.2 when fully charged nor less than 1.13 when discharged. It decreases proportionately as the cell discharges. The voltage of a cell on open circuit, that is, with no current flowing, is approximately 2.1 volts. This value is reached very shortly after either charge or discharge ceases, though it is somewhat influenced by the strength of the acid, temperature and, to a minor extent, by the state of charge. During discharge the voltage drops, the rate of decrease depending on the rate of discharge and its duration. Toward the end of discharge, the voltage falls off rapidly; when this point is reached the cell should not be further discharged. Conversely, during the charging period the voltage rises. Toward the end of the charge the rise of voltage is quite sharp and, the conversion of the lead sulphate formed during the previous discharge being fairly complete, the water of the electrolyte begins to decompose into its elements, hydrogen and oxygen. When the charge is complete, practically the entire input of electrical energy is used in effecting this decomposition and vigorous "gassing" ensues; then the strength of the electrolyte and the voltage cease to increase.

All of the materials of the plates, the lead, spongy lead, lead peroxide and lead sulphate, are practically insoluble in the sulphuric acid of the electrolyte, especially when there are no traces of other acids present. For this reason the plates are quite permanent. Great care is taken to attain the maximum purity of all materials of the plates and electrolyte so that the action described will not be undesirably varied or modified.

The lead sulphate formed during discharge has a greater volume than either the spongy lead or the lead peroxide; consequently, there is expansion and contraction of the active materials. The lead peroxide of the positive plate being somewhat noncohesive, it is gradually ground up and during the subsequent gassing at the end of charge some of it falls off, forming sediment. In the normal action of the cell the lead underlying the lead peroxide is very slowly corroded, forming new active material. With proper operating conditions the amount of new active material thus formed should balance the amount which falls off as sediment. The spongy lead of the negative plates being quite cohesive, it does not fall off if the cells are kept free from short-circuits and foreign materials, but it gradually becomes somewhat more compact and through the diminution of its porosity the capacity decreases. The rate of this decrease is greatest at the start and finally becomes very small. The negative plates are given sufficient initial capacity to provide for this shrinkage. If, in time, these plates show less than their rated capacity, they may be reversed by separately charging, with the proper precautions. This process causes the material to again expand and the initial capacity is restored.

In the action of the cell some water is lost through decomposition toward the end of each charge; this evaporation is made up by adding pure water to the electrolyte. It is usually necessary to add acid only when cleaning and removing the sediment. As already intimated, both the acid and the water used for making the electrolyte and replenishing it must be as near absolute purity as possible. Foreign acids (organic impurities are usually converted to acids in the action of the battery) must not be

allowed to get in; they lead to rapid corrosion of the positive plates. Other impurities lead to local actions with consequent loss of charge and must therefore be avoided.

If a lead-acid cell is allowed to stand partly or wholly discharged for any length of time, the normal action is also de-

FIG. 1. SAND TRAY

parted from, especially at the positive plates. The active material is with difficulty converted back to peroxide and the underlying lead may be rapidly corroded under certain conditions. Charging should therefore follow a discharge as soon as practical.

CELL STRUCTURE AND MOUNTING

Storage-battery cells for light and power plants are usually provided with either glass jars, glass tanks or lead-lined wooden tanks. The smaller cells are usually put in glass jars each of which is set on a bed of sand contained in a glass or wooden tray; the sand tray is supported by four glass insulators placed under the corners, as shown in Fig. 1. Cells of medium capacity are usually built with tanks of pressed glass; no sand trays are used, the glass tank resting directly on the glass insulators except for small cushions of either lead or rubber interposed to keep the hard surfaces of the two glasses out of contact.

Cells of the glass jar or glass tank type are the easiest to install because the plates are grouped at the factory. The plates of each cell are connected by cross-bars and terminal straps of lead, the negative plates to one cross-bar and the positive plates to the other as shown in Fig. 2. The plates and straps are connected by "burning." The cells are connected to each other by bolting the lead terminal straps together with lead-covered brass bolts.

Lead-lined wooden tanks are often used for plates of medium size and always for those of large size. The plates of this type of cell are grouped at the place of installation by lead-burning the lugs of the positive plates to a common bar and the negative plates to another bar. Fig. 3 shows how a tank cell of this type should be mounted.

All types of storage cell are usually installed with the supporting insulators resting on wooden stringers, these stringers having been previously covered with two or three coats of acid-proof paint. Cells of smaller types which are not too heavy are generally installed on two-tier wooden racks in order to economize floor space. The large cells are installed all on a single level, the wooden stringers being supported by vitrified brick set upon the floor or by another set of glass insulators resting on vitrified tiles.

Batteries should be installed in rooms especially prepared for them. The rooms should be dry and arranged for maintaining a moderate temperature during cold weather, otherwise the capacity of the battery will diminish by reason of the reduction in temperature. The batteries should also be located so that they will not be subjected to artificial heat during

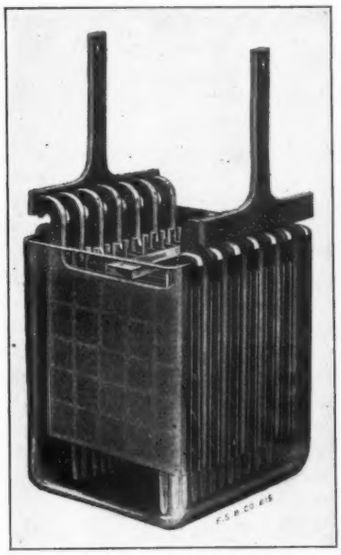


FIG. 2. CELL IN GLASS JAR

the summer and the temperature thereby raised above that of the external air.

Provision for ventilation and the removal of acid fumes should be made. The floor should be of asphalt, tile or cement, the last-named being the least desirable, and should slant slightly toward discharge drains in the floor. All copper work should be coated with tin or lead and all other metal work should be covered thoroughly with an acid-resisting paint. The cells should be arranged so that each one may be easily inspected and tested.

INSTRUMENTS AND IMPLEMENTS

For the proper care and inspection of the batteries certain accessories should be provided. One of the most important of these is a low-reading voltmeter with a range of zero to three volts; it should be accurate and of such design that its needle quickly comes to rest. A substantial thermometer should also be provided, in order that the temperature of the electrolyte can be ascertained. Its mercury bulb should not be too thin; if broken while in a cell, the mercury would damage the tank lining and the plates. A hydrometer is indispensable because its use is for testing the strength of the electrolyte, which must be done frequently. It comprises a weighted glass bulb with a long graduated stem and is used in the following manner: Some of the electrolyte is siphoned out of the cell to be tested into a tall cylindrical jar, large enough in diameter to contain the hydrometer; enough liquid is withdrawn to float the hydrometer. The number on the scale of the hydrometer at the point where the liquid surface is in contact with the stem is the specific gravity of the liquid, expressed in degrees. The specific gravity varies with the temperature and it is therefore necessary to reduce the readings to a standard temperature, which is taken as 70 degrees Fahrenheit. The correction is approximately 0.001 degree specific gravity for each three degrees by which the actual temperature differs from 70 degrees; the correction is added if the liquid is warmer than 70 degrees and subtracted if it is cooler.

A convenient means for ascertaining the specific gravity is a hydrometer syringe, which consists of a glass tube about an inch in diameter, one end of

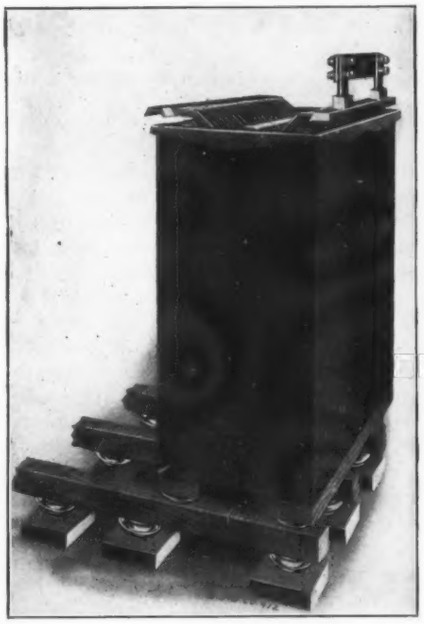


FIG. 3. METHOD OF MOUNTING A WOODEN TANK

which is drawn down to a nozzle of small diameter to take a rubber hose and the other end is closed by a large rubber bulb. A hydrometer is contained in the barrel of the syringe and by squeezing the bulb, inserting the rubber tube in the electrolyte and then releasing the bulb, sufficient acid can be drawn into the tube to cause the hydrometer to float and give a reading.

Soldered joints cannot be used in the cell proper and their use on connections

outside of the cells must be practised with caution. Soldering fluxes must not be allowed to get into the cells even in the minutest particles. In repairing, all joints must be made by lead burning. In this process a hydrogen flame is used which frees the melted lead from any slag, whereupon it welds readily. The hydrogen generator and the balance of the outfit can be obtained from dealers in storage battery supplies but it must be employed only after thorough instructions, as accidents may readily result through ignorance of the precautions to be taken.

In making bench tests of a battery it is advisable to know the relative condition of the positive and negative plates of the different cells. This may be done on the discharge of the battery by reading the voltage between either group of plates and an auxiliary electrode, preferably of cadmium, immersed in the electrolyte but not allowed to touch the plates. Cadmium can be obtained in sticks about a quarter of an inch in diameter and 6 inches long. One end of the stick should have a terminal wire soldered to it and over the other end should be drawn a piece of perforated pure soft-rubber tubing long enough to cover about three-quarters of the length of the stick. It should always be immersed in a glass of electrolyte for several hours before using. Cadmium sticks, properly made up, can be procured from storage-battery supply dealers and manufacturers.

The Electrolyte

It is always preferable to purchase the electrolyte already mixed and of guaranteed purity. If, however, concentrated acid is used in preparing electrolyte, the latter should be made by pouring one volume of pure concentrated acid of 1.84 specific gravity into about five volumes of distilled water. The vessel used for mixing should be preferably a lead-lined tank unless the quantity is small; then a vessel of hard rubber, earthenware or glass is suitable. In mixing the electrolyte, always pour the acid into the water very slowly and constantly stir the mixture, as much heat is generated by the mixing of acid with water. Never pour the water into the acid, as the resulting splashing is liable to cause painful and dangerous burns. The solution must be left for several hours to cool. Never add hot or even warm electrolyte to a cell, as the plates are liable to be very badly sulphated by so doing. The strength of the electrolyte should always be tested by a hydrometer reading, reduced to 70 degrees Fahrenheit. It is always advisable to use distilled water for the preparation and replenishing of the electrolyte because ordinary city water usually contains foreign substances of an objectionable nature.

Charging

As soon as the electrolyte is poured in the cells, charging should begin, because it hurts the plates to stand in the liquid without being charged. The first charge should be carried on for a much longer period than the subsequent or working charges, as it virtually completes the formation of the plates.

The positive terminal of the generator must be always connected to the positive terminal of the battery. The charging process commences at about 2 volts per cell and rises to approximately 2.6 volts at full charge while taking current at the normal rate specified by the maker. The first charge should be continued for at least ten consecutive hours, and twenty or thirty would be preferable. The first charge is usually about twice the capacity of a battery, and should be made at the normal current rate.

The specific gravity of the electrolyte will drop during the first few hours of the first charge but will rise again as the process continues; its maximum point is reached at full charge.

As the charge nears completion, bubbles will rise from both plates and the charging current should then be reduced, as the active material is almost fully formed and therefore cannot take up all the gas set free from the decomposition of the acid at the normal rate. As the amount of the gas liberated is in proportion to the current flowing, gassing will decrease when the current is decreased. It will take from twenty to thirty charges to fit a new battery to give its full capacity, and it is well to charge for 25 per cent. longer time at the normal current rate for the first few months. In ordinary work the battery will retain its normal condition with a charge of 10 per cent. in excess of the discharge.

During ordinary charging the normal rate or lower should be used, except in case of emergency. Under normal conditions 2.5 volts may be considered full charge, although the battery can be charged higher than that. After repeated charges, the water in the electrolyte will have evaporated to such an extent that the reduction in volume will expose the top of the plates unless water is added; this should be done through a hose or tube reaching to the bottom of the cell, as water added otherwise will stay on top, being lighter than acid.

Although it is not always the most economical procedure, the highest efficiency and longest life are obtained when the battery is charged slowly, never exceeding the normal rate. Conditions of plant operation will determine the most economical practice for each installation.

Discharging and Care

When discharging at the normal rate a battery should never be discharged below 1.8 volts per cell. In discharging at a higher rate than normal, however, 1.8 volts per cell will be reached before the battery is discharged to the same condition as at normal discharge, owing to the internal resistance producing a greater drop of potential, in accordance with Ohm's law.

The battery cells must be kept clean and the terminals covered by a coating of vaseline. Corroded copper, iron or any other foreign materials must not be allowed to get into the cells. If through accident this occurs, all of the electrolyte in such cells must be thrown away and new electrolyte put in them. Matches or exposed flames of any kind must not be allowed near a battery, especially when it is being charged, because the gases then given off are combustible and, if sufficiently concentrated, explosive. Temperatures higher than 100 degrees Fahrenheit should be avoided because the corrosion of the positive plates is accelerated by such temperatures.

Each cell should be tested with a voltmeter and hydrometer once a week. Any cell showing low voltage should be examined thoroughly for any foreign substance that may have short-circuited it. This will be indicated by a low specific gravity and deficiency or absence of gassing, the voltage rising slowly at the end of a charge when it should rise rapidly.

When inspecting and overhauling battery cells it is best to have them in a suitable battery house, placing the cells on a bench. Any sediment should be removed and the deficiency of electrolyte resulting from the sediment removal should be made up by the addition of fresh electrolyte.

Cells in poor condition can always be recognized through certain characteristics. The plates may be of poor color; the color of a wet positive plate in good condition varies from rich dark brown, almost black, when the plate is fully charged, to a reddish, chocolate brown when discharged. A light grayish coating on the positive plate is not a bad indication if by rubbing with a clean stick or a piece of hard rubber the proper color is evident under the surface. The color of dried plates is much lighter. Wet negative plates are of a light slate-gray color when charged and somewhat darker when discharged. When dry they are considerably lighter and may be even somewhat yellowish if allowed to heat in drying. If the color of a plate is not as described, it is probably sulphated. If the voltage of a cell is conspicuously lower during discharge or higher during charge than it should be, sulphating (the formation of lead sulphate on the active material or between it and the lead supporting grid) is indicated. If the strength of the electrolyte is low, the cell should be investigated for short-circuits or sulphated plates. Always be sure that the sediment does not touch the plates; it must be removed as soon as there is danger of contact occurring.

Usual Causes of Trouble

Plates may get in poor condition from any of the following causes:

Impure Electrolyte—This may be due to a poor quality of acid being used at the start or to the use of impure water or to foreign substances getting into the cell. The remedy, if the plates are in fair physical condition, is to displace the old electrolyte with new when the cell is in the discharged condition and then to give the battery a thorough charge.

Short Circuits—These are not frequent if the sediment is removed before it reaches the plates. When they do occur, the cell should be completely dismantled, the plates straightened and the cell assembled again, the separators being completely replaced. The cell should then be thoroughly charged.

High Temperature—At a temperature above 100 degrees corrosion is rapid. If it be possible to prevent it, the temperature should not exceed 90 degrees. The positive plates may be sulphated considerably from this cause and be considerably distorted. If they are thoroughly corroded, they must be displaced by new ones; if not, they should be discharged, straightened and recharged. The conditions should be changed so that the battery will not again be subjected to high temperature.

Standing Discharged—The positive plates are especially liable to be badly sulphated from this cause. The indication of this condition is a light color of the positive plates, possibly with blotches of grayish color. The remedy in this case is also a complete charge, though care must be taken that too much active material is not thrown off during the charge. The active material under this condition sometimes becomes quite granular and noncohesive; if it comes off easily the cells must be alternately charged and discharged until the plates are restored to normal condition.

General

In all cases of recharging a cell after treatment, the charge should begin at the "starting" rate of current and be kept at this value until vigorous gassing begins. The current then may be reduced to the "finishing" rate, at which it should be maintained until both the electrolyte and the voltage have remained at constant values for six or eight hours. If too much active material is thrown off by the gassing of the cells, the charge should be discontinued and the cells discharged, the subsequent charge being carried out as explained in the beginning of this paragraph. This process is to be repeated until the plates are again of good color and in good condition. Charging rates less than the "finishing" rate must not be employed under any condition; low charging rates are especially injurious to cells in poor condition.

The excessive use of water in cleaning batteries should be discouraged; it causes the positive plates to sulphate and lose their charge rapidly. The plates may be rinsed by dipping each group into a comparatively large tank filled with electrolyte. A good procedure is as follows: First, see that the battery cells are fully charged and provided an extra tank or other container suitable for immersing the plates. Remove an element from its tank and take out the separators, making sure that the plates are free from any particles liable to cause short-circuits. Replace the old or apply new separators and rinse the element in the clean tank which has been previously filled with electrolyte of the proper specific gravity. Special care should be taken that the plates are kept out of the electrolyte as short a time as possible because the air coming in contact with the negative plates causes them to heat and lose their charge. If the transfer is quickly effected, this method will be very efficient. The battery should then be charged until the specific gravity has ceased rising and remains stationary for one hour. Should any of the cells not come up in voltage along with the others, they should be disconnected from the battery and treated separately. The specific gravity of the electrolyte should then be adjusted to the proper strength. If time permits, it would be well to make a capacity test to make sure that the battery is in serviceable condition.

If the method just described cannot be carried out, the positive plates may be allowed to stand in the air for several hours without any damage, as the plates dry out slowly and do not lose much of their charge. The negatives, however, must be at once immersed in water or electrolyte, preferably the latter, for the reason already given.

LETTERS

Water Tank Signal Systems

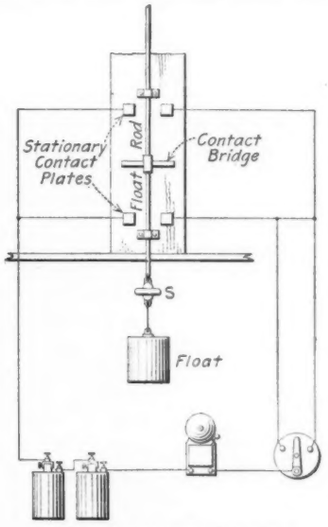
It seems to me that the water-tank signal system described in the March 28 issue may be improved as indicated by the accompanying sketch, which is practically self-explanatory. Only one bell is used instead of two and the battery wire has no motion and therefore no tendency to break off; moreover, provision is made in the insulating coupling *S*, to avoid grounding through the water.

The contact on the rod shown in the March 28 diagram is liable to turn away from the stationary contacts because the rod inevitably will revolve. The shape of the contact on the rod shown in this sketch will make such an occurrence impossible.

Alexander Dolphin.

Jamaica, N. Y.

The accompanying sketch represents a system that I installed some time ago and have been using satisfactorily ever since. It consists merely of a wooden lever pivoted near one end on which are mounted two contacts, made out of an old clock spring, and to the long arm of which are attached the float and counterweight suspensions. In line with the spring contacts are stationary contact plates, *C* and *C*, connected to the two-way test switch. To allow the use of only one bell, that one is connected between the switch and the battery; the return circuit is through the water-piping instead of a third wire. The operation is obvious from the diagram.



Mr. Dolphin's Diagram

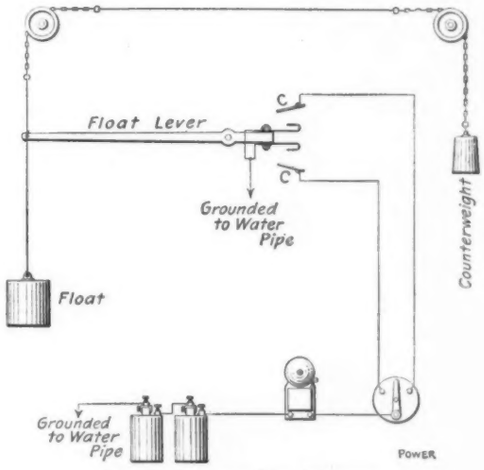


Diagram from Mr. Wright

John A. Wright.

Jamaica, L. I.

[The use of one bell, connected as shown in both of these sketches, has also been suggested by Norman W. Casper, New Burnside, Ill. It is, of course, preferable to the two bells originally shown.—Editor.]

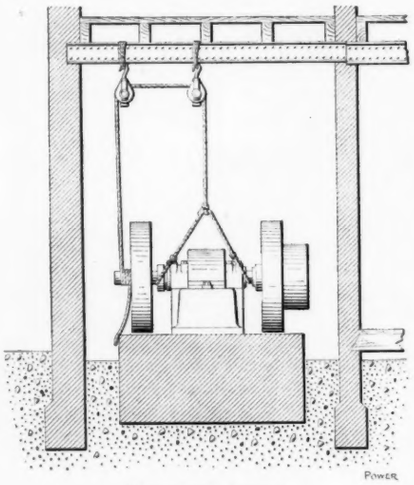
Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Making an Engine Lift Itself to the Foundation

By F. B. Hays

A short time ago I was called upon to set on its foundation a horizontal gas engine weighing about 1500 pounds. There was no crane, hoist, derrick or other lifting mechanism available, nor any means of installing anything of the sort if we had had any. The foundation bolts were very much out of alinement, due to a mistake on the part of the masons who built the foundation, so that the bolts would have to be sprung into the holes in the engine frame as it was let down into place. The space in



Hoisting Itself

which the engine was to be set was so small that only two men could work on the job at once, and there was no room to use pinch bars or levers long enough to be of any advantage. In short, the job seemed almost hopeless until the plan which we followed was devised.

Just above the engine there was a heavy beam capable of supporting a couple of tons of weight. Two single-sheave pulley blocks were attached to this and a rope was fastened around the engine frame and run through the pulley blocks to the engine shaft, around which it was given several turns, as illustrated in the accompanying sketch. By revolving the flywheel of the engine, the shaft acted as a windlass and the engine could be raised or lowered with facility.

One man was placed at the flywheel to raise or lower the engine, while another one sprung the foundation bolts into the holes of the engine bed. By this means the engine was raised and lowered to its foundation with very little difficulty.

Development of the Gasolene Engine*

By Joseph C. Riley†

The development of the gasolene engine has been more rapid than that of any other form of motor, not even excepting the steam turbine. We all recollect with what curiosity, not many years ago, we regarded the new horseless carriages and how we wondered whether the noisy little engines which left a smell of half-burned gasolene behind them would ever become really desirable motors. The first part of this period of development saw radical changes in the design of these motors, but the use of light oil had come to stay. Although dangerously inflammable and five times as dear as the heavier grades of petroleum burned in larger oil engines, the cleanliness of gasolene and the ease with which it can be prepared for combustion are alone sufficient to dictate its use.

The gasolene engine has profited enormously by the rapid advance in all branches of mechanical work. Its own special improvements have been, for the most part, such as would naturally come from the thousands of ingenious designers, skilful mechanics and experienced motor-car drivers who have tested and tried it under all possible conditions of service. As a result, advancing by process of trial and error, the engine has reached a fair degree of perfection in two points at least: It has been made to develop greater power per unit of weight than any other form of prime mover and its reliability has been advanced to the stage which warrants its use even for such exacting service as propelling a lifeboat or driving a fire engine.

Little of this development, however, has been made possible by what may properly be called scientific study of the engine's performance. At first there was scarcely time for such work. The demand for engines was often greater than could be supplied, so the engineers' efforts were concentrated on increasing the factory output as fast as possible, consistent with a fair improvement in the product. The time for refinement in design had not yet come. Thorough trials of an engine with all its accessories were usually carried out to make sure that everything was assembled and adjusted well before the product was sold, but measured tests for anything except the power output—under somewhat uncertain conditions—were not considered necessary.

Aside from differences in general excellence of mechanical construction caused by variation in design, unquestionably there are inherent differences in the power developed by different engines and in their fuel economy. When operated at the piston speed corresponding to maximum power (a speed usually between 1100 and 1500 feet per minute) the best automobile engines give results nearly 50 per cent. better than those from the poor ones. But little of this discrepancy can be charged to imperfection of the mechanism causing surface friction, for even the cheaper motors are well built in this respect. It is influenced by the quality and quantity of explosive mixture, the amount of compression, the time and rapidity of ignition and the timing and size of the valves.

The interrelations of these many factors are very complex, but they may be summarized by saying that the power depends upon the pressure in the cylinder. The variation in the force behind the piston as it moves in and out is what does the work; the time at which pressure is applied and the rate at which it changes consequently determine the amount of work realized. The more we know about just how the pressure varies the better able we are to devise means for controlling its rise and fall and thereby producing a greater net output. The piston type of indicator has been of service in analyzing the performance of internal-combustion engines of moderate speed but for light-weight engines such as are used for driving automobiles, aëroplanes and small boats, the speed is

*Abstract of a paper presented before the Congress of Technology at the fiftieth anniversary of the granting of the charter of the Massachusetts Institute of Technology.

†Assistant professor of mechanical engineering, Massachusetts Institute of Technology.

much too high for any of the ordinary commercial forms of indicator. The natural cadence of vibration of the indicator springs and moving parts is altogether too slow for anything like such high speeds; the waves introduced into the diagram by violent explosions would be too long and might be misleading.

What is needed is a recording mechanism with a period of vibration of high frequency, more like that of the electrical oscillograph, say between 500 and 1000 per second. Moreover, if incorrect deductions are to be avoided, great care must be taken to insure that the indicator diagram starts from its dead points exactly in phase with the engine piston. Within the past three or four years optical indicators capable of producing satisfactory results at 1000 revolutions per minute and upward have been used in research work in a few technical schools and private testing laboratories. They cannot be handled successfully, however, except by skilled observers and in general they cannot be used at all with the engine in actual service. The engine must be mounted on a rigid testing block and studied under artificial, ideal conditions.

Little improvement in power can be expected from the best engines; they are already excellent. There are automobile and marine engines today, working on the four-stroke cycle, that give mean effective pressures above 100 pounds, even when driven at extremely high speed. On the other hand, there are small two-stroke marine engines, the mean effective pressures of which range anywhere from 85 down to less than 60 pounds, depending on how well or how badly the fuel charge is supplied, exploded and rejected. The energy wasted in getting the charge into a three-port engine, or in dragging it into the crank case against the pressure of a check valve with too tight a spring, or blowing it into the cylinder after needlessly high compression, materially decreases the horsepower output. In some of the poorer engines the entering charge is further obstructed by insufficient passages through the carbureter; the charge is not merely throttled, it is fairly strangled; the wonder is that it gets in at all. Crank-case diagrams from such engines would set the designers to thinking.

Between the better and the poorer designs of gasolene engines there are wide margins in power, to say nothing of fuel economy. The dynamometer shows that they exist, but it does not show whether deficiency in power is due to constricted passages, defective ignition and combustion, or any other definite fault. Now, the scientific way to remedy a defect of any kind is to begin by investigating first its magnitude and then its cause; and the instrument adapted to such a study in the case of the gasolene engine is the indicator—in the "half-size" pattern within limits and in the optical type beyond those limits.

With all fast-running reciprocating engines the necessity for arranging the cylinders to secure regularity of driving effort and for balancing the moving parts to prevent excessive vibration is apparent. Good mechanical balance is particularly desirable for the class of engines discussed in this paper. The best engines for automobiles, boats and aëroplanes give evidence of having been planned by men trained in the principles of dynamics, as well as in all other elements of mechanical design. Some builders, however, have but hazy notions on methods of balancing. In fact, they seem to associate vibration with the sudden rise in pressure due to explosion within the cylinder, as if the shaking of the frame were due to the shock of explosion. That vibration results from the motion of the masses and that it would be practically the same even if the cylinder heads were removed and the shaft were revolved by power supplied from some other source is new to them.

There are many problems which arise in the design of machinery which cannot be solved even approximately until after the machine is built and tested. The experience gained by operation of the first few imperfect machines then furnishes the information required for modifying and improving existing forms, in varying sizes and powers, and thus the machine is gradually perfected without the application of purely theoretical reasoning.

CORRESPONDENCE

An Inconsistent Engine

If the engine described by Mr. Hall in the March 28 issue does not run faster than normally when *all* the priming cocks are open, the mixture cannot be at fault, except in the unlikely event of each cylinder having a separate air intake. In this case it is possible that No. 3 is not getting enough air for some reason. The first thing to do is to verify the timing of the spark in No. 3 cylinder. It is possible that the spark is timed so as to cause slightly premature ignition and excessive back pressure is relieved by opening the priming cock. Preignition from incandescent deposits or from gas burning in pockets might be the cause of such back pressure; but as the engine is said to be in good condition, this does not appear to be likely to be applicable to this case.

The valve gear of cylinder No. 3 should next be gone over as to the timing of opening and closing and the amount of lift and compared with the settings for the other cylinders. If the valve motions are the same as for No. 2 cylinder and if Nos. 2 and 3 cylinders are fed by a symmetrical manifold from a centrally connected carbureter and No. 2 cylinder does not behave the same way, it is permissible to ignore the possibility of the nature of the charge or its distribution being to blame. If, however, the manifold is so shaped or the carbureter so located that No. 3 gets more than its proper share of gas, it is just possible that, provided all the compression spaces are of equal volume, with normal valve lifts and timing, the compression in No. 3 may be too high, and this, in conjunction with a rich mixture and early timing, might cause the trouble.

All these theories may sound rather far-fetched to those who are not acquainted by experience with the immensity of the range of vagaries that a gasolene engine can display on occasion; but as Mr. Hall did not give any data to enable one to eliminate anything and as I have never observed a similar stunt on the part of a gasolene engine, they are put forward for what they may be worth, which may or may not be much.

If Mr. Hall solves the problem it will be interesting to learn the cause of the trouble, how it was traced and how it was remedied.

JOHN S. LEESE.

Manchester, England.

Mr. Hall's trouble is probably due to faulty ignition. Should the charge taken into cylinder No. 3 not be fired, the engine would be working against the compression in that cylinder. Opening the pet cock on this cylinder would, of course, relieve the compression and reduce the amount of work that the remaining three cylinders have to do, thereby speeding up the engine.

DONALD RENSHAW.

New Orleans, La.

Corrosion of Water Cooled Exhaust Pipes

I am in charge of a gas-power plant in which the engines were formerly arranged so that the exhaust gas was cooled by injection of water from the cylinder jackets. After a few months' operation the exhaust piping was so corroded by the action of what appears to be sulphuric acid that it had to be replaced.

I am now running without the water injection and obtaining good results as far as the exhaust piping is concerned. I would like to know if any other readers can tell me how to overcome this difficulty so that I can cool the exhaust gas without detriment to the piping. I have tried cast-iron and wrought-iron pipe with the same result.

JAS. W. WILD.

Garfield, N. J.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Isolated Power Plant Makes a Good Showing

The original mechanical equipment of the Missouri Baptist Sanitarium, St. Louis, Mo., consisted of two high-pressure return-tubular boilers, furnishing steam for heating and domestic purposes; light and power, however, were purchased from a central station. This arrangement was in force for over ten years.

During the year 1905, a small engine and generator were installed which furnished a portion of the light, and the results were so gratifying that a complete plant was installed during 1908. The new equipment consists of two return-tubular boilers of 100 brake horsepower each; two 60-horsepower, 10x11-inch piston-valve engines that drive two 35-kilowatt, 125-250-volt direct-current generators. The lighting load consists of 540 sixteen-candlepower lamps distributed throughout the institution, a motor load of 47 horsepower for operating laundry, elevators, ventilating apparatus, pumps, etc., a total load of 68 kilowatts.

The buildings are heated by exhaust steam, both direct and indirect methods being employed. The total heating surface is 11,282 square feet. The demands upon a plant of this type are exacting and require heat, light and power throughout the year. The entire equipment is in duplicate, and the service has been uninterrupted since starting the plant, nearly two and half years ago.

The cost of heat, light and power for the fiscal year of 1904, which was the year preceding the installation of the small generating unit, was $5955.09, and of the fiscal year of 1910, the second year after a complete plant was installed, the cost of operation, including cost of fuel, labor, all supplies, maintenance, etc., as charged on the treasurer's books, interest and depreciation on electrical equipment, was $4958.86, a saving in 1910 over 1904 of $966.23. These figures do not take into consideration the fact that the light, power and heat have been materially increased since 1904. For instance, the increase in the lighting load over that of 1904 is 54 per cent.; increase in connected power load over that of 1904, 92 per cent., and the increase in the heating system, 22 per cent.

The cost of heat, light and power for 1910, if electrical energy had been purchased, as in 1904, would have been $7444.86. The cost of this service from the isolated plant represents a saving of $2486.

In this instance the engines, generators and all additional equipment necessary for the electrical plant cost a little less than $6000. The saving in the fiscal year ending with September 10, 1910, over and above the cost of current and heat, if current had been purchased as in 1904, would show a net return on the investment, after allowing for interest and depreciation, of over 40 per cent.

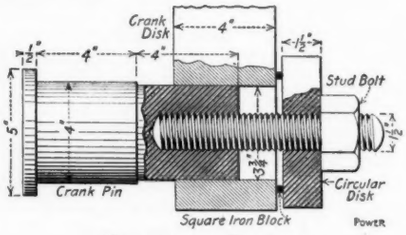
The present service is more satisfactory than the original arrangement, and the splendid showing is due to high-grade equipment and the intelligence with which it is handled.

VICTOR AZBE.

St. Louis, Mo.

Crank Pin Repair

The accompanying illustration shows a method used in putting a new crank pin in the crank disk of an ammonia compressor. The original pin became loose in the disk and a new one had to be fitted in as short a time as possible.



DETAILS OF REPAIRS

The new pin was made at a local shop and had a hole drilled and tapped in the center for a ½-inch stud bolt. The hole in the disk was reamed out 1/32 inch larger than the original hole in order to get it true; the pin was turned for a 20-ton pressure fit.

The pin was started into the hole and a washer put on the back side of the crank disk, with two pieces of square iron between them to act as distance pieces.

The stud, having been screwed into the pin, was slipped through a 1⅝-inch hole drilled in the circular disk and a nut screwed on. While one man with a 24-inch wrench took up on the nut, two others, with a heavy block of wood, driving the other end, soon had the pin in place. The next step was to rivet the back end of the pin over on the disk.

Since this repair was made the compressor has been running constantly for about 12 months and the pin shows no signs of working loose.

D. M. GROVE.

Covington, Va.

Changing Shifts

There are a number of ways by which men who are working 8-hour shifts can change from one shift to another at regular intervals. Suppose that the hours for relieving the watch are at 7 a.m., 3 p.m. and 11 p.m.,

Of the various ways of changing, the following two methods are most commonly used. First, by the night crew working a double header of 16 hours, say from 11 p.m. Saturday until 3 p.m. Sunday. The crew that has been working the 7 to 3 shift lay off from 3 p.m. Saturday to 3 p.m. Sunday, and the crew working from 3 to 11 p.m. lay off from 11 p.m. Saturday until 11 p.m. Sunday.

The second plan is for the men going off the 7 to 3 watch, to lay off for 32 hours, that is, from 3 p.m. Saturday until 11 p.m. Sunday. The men coming off the 3 to 11 watch have an eight-hour lay off and come on duty at 7 a.m. Sunday. The night-watch men get through work at 7 a.m. Sunday, and return to work at 3 p.m. the same day.

There is another plan that I have seen worked which I consider very much more advantageous to the men, for the reason that they get one day off duty. By this plan the crew that quits work at 11 p.m. Saturday lays off until 7 a.m. Monday. They thus have all day Sunday free from any thoughts of having to go to work, which would not be the case with either of the other plans. The men who have been working from 7 to 3, lay off from 3 p.m. Sunday until 11 p.m. the same night. The men coming off duty at 7 a.m. Sunday return to work again at 3 p.m. that afternoon. Where this plan has been tried the men rarely wish to give it up for any other.

H. X. GSKHE.

North Cambridge, Mass.

Condensing Apparatus

Some time ago, while talking with the chief engineer of a large power plant, we fell to discussing condensing apparatus and surface condensers in particular, bringing out some points that are usually taken for granted without very much thought as to the why and wherefore.

One of the first things considered was the location of the dry-air pump and the advantage gained by placing it as close to the condenser as possible. Upon first thought it may seem that the location of the dry-air pump in relation to the condenser is immaterial as long as all the joints, etc., in the dry-air line are kept tight and free from leaks; but suppose, for example, that the temperature of the room where the condensing apparatus is situated is above the temperature of the condensation; then if the pump is placed at a considerable distance from the condenser the air has to travel through a long line exposed to this higher temperature which, consequently, increases the volume of air, forcing more work on the pump and usually resulting in a drop in vacuum. Of course, the conditions may be such that it would be impracticable to have the air pump close to the condenser, in which case the usual method employed to overcome the difficulty is to cover the dry-air pump with a good thickness of lagging.

The next point brought to my attention was the proper size of pipe to use and if any advantage was to be had by using a larger pipe than that for which the pump was designed. For instance, if the diameter of the intake port of the pump were 6 inches, would anything be gained by running a 12-inch line from the condenser to the pump instead of a 6-inch line, as would naturally be the first inclination?

The main object of an air pump is to get rid of whatever air collects in the condenser as quickly as possible and, as pipe friction is something to be taken into consideration, it would seem plausible that the larger the pipe the less the effect of friction, but as there is only a very small quantity of air passing through the pipe the friction is practically negligible; on the other hand, the larger the pipe the more surface is exposed to the effects of the outside temperature.

There is in use in a certain steam plant a combined wet- and dry-air pump of a rather original design. This pump is steam driven and has separate cylinders for air and condensation. The dry-air cylinder exhausts into the wet-air or water cylinder between the foot valves of the wet-air cylinder and the cylinder itself, having to pass through two valves in a small valve chamber located at the bottom of the cylinder. When new, this pump used a normal amount of steam to drive it and was controlled by a throttling governor, but after being in service for several years the pump developed a decided tendency for speeding up and could only be controlled by the throttle.

The logical explanation seemed to be that the governor was badly in need of repairs, but after having been thoroughly overhauled and replaced on the pump the conditions were not changed in the least. Finally the governor was cut out altogether and the pump run on the throttle. This pump is now running with the throttle open a little less than one-quarter of a turn and yet the vacuum is as high, if not a little higher, than it ever was, which causes one to question if sometimes it is not possible to get something for nothing. All other conditions have remained the same, but there is a reason and I would like to hear an opinion from some of the readers of POWER as to the cause of this peculiar condition.

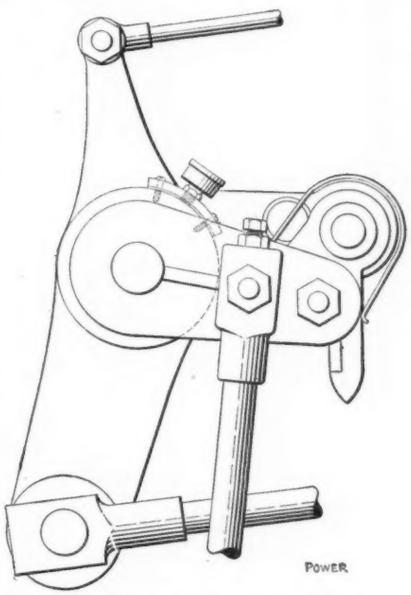
HOWARD BARR.

New Rochelle, N. Y.

Lubricating the Bell Crank

While visiting an engineer recently, I was interested in his method of lubricating the valve gear of a Corliss engine, as shown in the accompanying illustration.

This engineer had hunted up two pieces of an old brass sectional piston, taken from an old pump, about ⅜ inch thick and 1½ inches wide. He fashioned these pieces to fit the outer surface of the bell crank and, drilling and tapping a hole for a ⅜-inch pipe, screwed a 2-ounce grease cup in place.



GREASE CUP ON BELL-CRANK BEARING

Two ¼-inch holes were drilled and tapped on each side of the slot in the bell crank and holes were drilled in the circular piece of brass plate to correspond. The plate was then screwed fast to the casting by 2¼-inch brass screws, first putting a piece of soft leather underneath for a packing to prevent the grease from squeezing out around the edges of the plate.

This rig enabled him to squeeze the double bearing full of grease at any time, thereby preventing any little noise and wear as the grease did not run through the bearing.

CHARLES H. TAYLOR.

Bridgeport, Conn.

Improved Engineering Conditions

It should be very encouraging to steam engineers to note the trend of things that vitally concern him. However, engineers are asking such questions as, "Are conditions becoming better or worse; if better, in what way; if worse, in what particular, and for what class are conditions becoming better or worse?" These are pertinent questions.

It is well to take a broad view of the field of work in which engineers are engaged. Three years ago, we had not a weekly paper devoted to operative engineering in this country. The monthlies, with two or three exceptions, were unpretentious, and the matter they contained would not compare in any way, either in quantity or quality, with that which is supplied today. The contributions and discussions in the technical journals evidence greater activity among operating engineers than ever before, which means that engineers are growing into a more respectable and respected class. One must be blind who does not realize that this change has taken place in many instances and the tendency is toward this condition generally.

A few years ago, fuel cost less than half what it costs now and everything used in the operation of a power plant cost much less than it does now. The charges for public service, however, have not kept pace with the increased cost of fuel, labor and supplies.

So long as fuel and supplies were cheap, employers did not look so closely into matters of fuel consumption and other items of expense in the production of power as they do now. These conditions call for better brains to meet them. Business men begin to see that the economical operation of power plants is a scientific proposition, instead of a mere matter of manual labor. From an engine- and boiler-room laborer, the engineer has become the adviser of the management. His position is fast becoming respectable. There is more ahead of the ambitious man at the lower rungs of the ladder than ever before and his prospects are becoming better every year.

Some years ago fuel was never purchased except by the ton. Now heat

units govern the price, and the owners of power plants are looking for the man who can turn the last available heat unit in the coal into effective work. They know that the man who can do this is not a cringing thing in greasy overalls, but is a man with real gray matter under his hat.

In the future it is going to be a scramble and a case of the "survival of the fittest." But with the means available for self-education, any man with a reasonable amount of "horse sense" will be able to get in line for the better things in store for the engineering fraternity.

There is ample room for improvement, but the manner in which engineers are meeting the changing conditions promises well for the future, both for the owners of power plants and for themselves.

Ten or fifteen years ago an engineer who could set the valves of a Corliss engine so that it would run at all was considered a very good man. Now we find them conducting hair-splitting discussions as to the proper hight of the compression curve, whether it shall be allowed to run to one-third or one-fourth the hight of the diagram, or less. Lead must be adjusted to a nicety that our fathers never thought of, and operating engineers are found laying off the lines for isothermal and adiabatic expansion on the indicator diagrams and checking the actual by the theoretical.

These things indicate that engineers are progressing, and will be, for several reasons, two of the most important being the increasing pressure of conditions, and the increased ease of obtaining knowledge and applying it. What the engineers of the past had to arrive at by long and tedious calculation is now obtained at a glance from handbook tables.

WILLIAM WESTERFIELD.

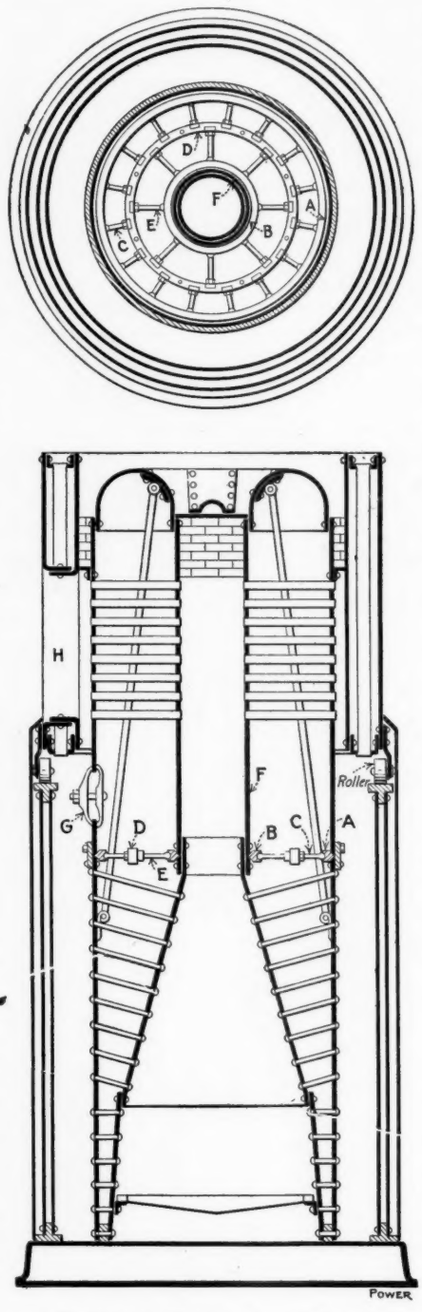
Concordia, Kan.

Novel Boiler Construction

While visiting a small boiler shop, I was shown a boiler that had features which were extremely novel. The boiler was destined for a mountainous part of the country where fuel was scarce and dear, and where transportation of the boiler from place to place would be difficult.

The accompanying illustration shows a sectional view of the boiler, but is drawn from memory and from such description as was detailed to me, and, therefore, is to be considered as simply portraying the chief features and not as accurately setting forth the constructional details. The boiler can be divided into two sections, at the joints *A* and *B*. The lower half of the strap at *A* is riveted and calked in the usual manner, but the upper half is only bolted on and is not calked. The joint is made tight by means of a triangular-shaped cast-iron ring, which fits accurately into the V-slot machined at the intersection of the two halves of the shell. The ring *A* is cut slightly larger than the inside diameter of the shell, like the packing ring of a steam piston.

Before being snapped into position, a narrow strip of a flexible alloy is placed in the bottom of the groove. When in



SECTIONAL VIEW OF THE BOILER

place, the packing ring is evenly set out by the bolts *C*, bearings for which are furnished by the built-up wheel *D*. The inner ring *B* is set by the bolts *E*, and the band *F* is riveted on to complete the joint at this juncture. The ends of the setting-out bolts are upset and rounded to fit into recesses in the packing ring to allow flexibility in case of unequal expansion of the inner and outer shells. Details of the bolts, wheel and packing rings are shown in the plan view. Some of the braces of the upper half connect below the joint to the shell of the lower half. On some of these braces are turnbuckles of a special make, which are used to raise the upper half clear of the other when dismantling the boiler. The two halves of the shell are guided to a correct position by two keys (not shown). Access to the interior of the boiler is obtained through a manhole, the position of which is shown at *G*.

As this boiler had to be operated under economical conditions it was necessary to have a large heating surface proportionate to the grate surface, which was difficult to provide without making the boiler too bulky. The designer, however, hit upon the plan of using a one-tube economizer for heating the feed water. By this means the waste gases are utilized to a certain extent, but the heating surface of the boiler is materially increased by compelling the gases to return along the outer shell before entering the economizer. But the economizer so covers the boiler tubes as to prevent access for cleaning them. To offset this the economizer was set on rollers, and a long but narrow door *H* cut in it. By disconnecting two unions, one on the feed-water inlet and one on the outlet, the economizer can be revolved entirely around the boiler, thus bringing the door opposite each row of tubes. The economizer is set on a framework of T and angle iron, around which is a covering of sheet iron.

The more one studies the design of this boiler, the more he recognizes the ease with which it can be thoroughly cleaned and repaired.

While this boiler may be expected to operate with a fair degree of economy, considering its type, there are several doubtful elements in the construction, which the reader will doubtless perceive.

R. O. RICHARDS.

Framingham, Mass.

Standpipe on Heating System

A certain heating plant will soon have to be extended in order to heat an annex to the main building. The job should be done as cheaply as possible as the building will be vacated next year. The old traps are overloaded, and a new trap is not wanted. The system is made up of 1-inch pipe, and operates by gravity. The pressure is from 5 to 8 pounds, and discharges through traps into an open tank and is then pumped into the boilers.

How about putting up a standpipe of a convenient hight and letting the water overflow into the open tank; would this work and, if not, what else could be done?

ALEX DOLPHIN.

Jamaica, N. Y.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

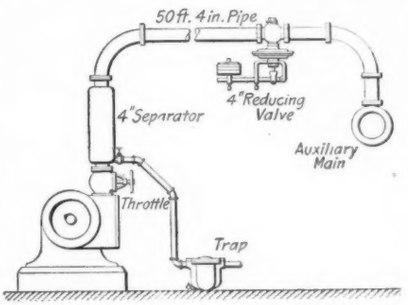
Specialists

I was interested in James Scotch's letter which appeared in the issue of March 21, under the above title. I believe that he writes too harshly of the "dinky little" engineer, who presumes to dictate to specialists summoned for especial work in his plant. Personally, I bear the opinion that the *thinking* man, be he engineer or coal passer, can, at times, present highly intelligent hints to any master-of-trade; especially is this so when the latter is one of that numerous class of craftsmen who have achieved proficiency in their vocation solely by imitation and who not only copy the merits of their models, but, likewise, commit their faults or, ignorantly, maintain a custom that has, since their apprenticeship, become obsolete. I refer to that large class of so called specialists who are adepts at doing things which they have seen accomplished before but who are easily confounded when asked for reasons why one thing is performed this way and another the other way. I contend that these men are but cogs in the huge industrial wheel and, compared with them, the little free-thinking engineer becomes "the man of broader education" that Mr. Scotch refers to "as the man who rises highest in the engineering profession" and, I may add, "sets the cog wheel in motion."

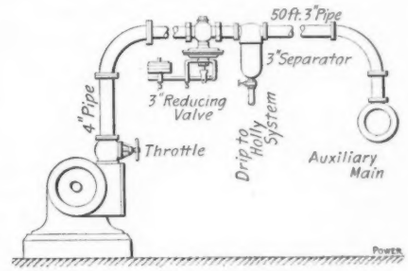
We all find it easy to criticize the handiwork of these specialists; but small indeed is the number of those who can suggest ideas that will correct the faults perceived. When, by concentration of mind, we are enabled to do this, and the expert finds the idea practical, have we not every reason to "crow" of our ability? And if the idea be worthy and general in its application, what better could we do with it than have it appear in the columns of POWER that others may profit thereby? As an instance for comparing a specialist and a *thinking* engineer I commend the following:

At the invitation of a friend whose plant was undergoing partial remodeling, I was present in the engine room when a steamfitter unfolded a blueprint upon which plans were drawn showing a method for connecting an old Putnam poppet-valve engine, built for 70 pounds steam pressure, to a battery of modern boilers capable of withstanding a pressure of 150 pounds. A portion of the drawing is reproduced in the accompanying figure. As a part of the improvements introduced, the Holly system of drainage had been installed.

When the plans had been duly inspected, the engineer desired to know what objections existed against placing the reducing valve on the engine side of the separator. He opined, if this was permissible, that a smaller-size pipe could be run for most of the distance, a smaller size of separator and reducing valve would suffice and that frequent source



Specialist's Plan



Engineer's Plan

of trouble, the trap, could be eliminated. Furthermore, he argued that the separator, if installed according to the specialist's plan, would be altogether useless as a means for reducing the *percentage* of moisture present in the steam as it is well within the bounds of reason to credit the steam upon leaving the reducing valve with more or less superheat, depending on the amount of moisture present in the high-pressure steam. Thus, the separator, according to my friend's supposition, would be curtailed in its functions to a mere safety device against the flooding of the engine and even this function would depend on the condition and capacity of the trap. In my estimation, the same object would be accomplished by a pair of well designed relief valves placed on the engine cylinder. In answer to all the arguments enumerated the specialist could invoke but one; that was: "It is not customary to install the apparatus in that arrangement"—a truly characteristic reply of the majority of his class when confronted with debatable reflections.

Of course, it is far from my desire to be understood to mean that there are no bright exceptions and, no doubt, I shall hear from some of these, who will deem it incumbent to swing the cudgels for their more unfortunate brothers, even as I do for the "dinky little one-horse engineer." Yet, it is my sincere conviction that any alert engineer, who keeps abreast of his times by reading, digesting, appropriating and using the thoughts and suggestions found in the abundant literature of his trade, can at times furnish pointers which NO specialist need be ashamed to accept.

OWEN R. OWEN.

Roxbury, Mass.

Size of Turbine Exhaust Pipes

R. M. Neilson, in the issue of March 28, gives an interesting formula for the area of steam-turbine exhaust pipes but he does not give the data from which it was derived. It appears that the formula is defective in not including the length of the pipe and the allowable drop in pressure between the condenser and the turbine or the ratio of these two quantities, or else Mr. Neilson has neglected to state what constant ratio of these quantities he used in constructing his formula.

I have made some calculations from the formula for two assumed cases: 1000 and 20,000 horsepower; steam consumption, 12 pounds per horsepower-hour, and 28 inches of vacuum.

The data from the Marks-Davis steam tables are:

V = Volume of one pound of steam = 350.8 cubic feet;

W = Weight of one cubic foot of steam = 0.002851 pound.

The formula is,

$$A\ (in\ sq.ft) = \frac{W^{0.8}\, V^{0.5}\, f^{0.4}}{16{,}000}$$

W = weight of steam in pounds per hour, and f is a factor for the cross-section of the pipe = 3.55 for a round pipe.

$f^{0.4} = 1.715$; $V^{0.5} = 18.73$

For 1000 horsepower,

$$W = 12{,}000;\ W^{0.8} = 1{,}834$$

$$A = 1834 \times 18.73 \times 1.715 \div 16{,}000 = 3.682 \text{ } \textit{square feet}$$

or 26 inches diameter.

For 20,000 horsepower,

$$W = 240{,}000;\ W^{0.8} = 20{,}140$$

$$A = 20{,}140 \times 18.73 \times 1.715 \div 16{,}000 = 40.44 \text{ } \textit{square feet}$$

or 86 inches diameter. The velocity of the steam in the first case is:

$$200 \textit{ pounds per minute} \times 350.8 \div 3.682 = 19.055 \textit{ feet per minute} = 318 \textit{ feet per second}$$

In the second case it is:

$$4000 \textit{ pounds per minute} \times 350.8 \div 40.44 = 34{,}700 \textit{ feet per minute} = 578 \textit{ feet per second}$$

The common formula for the flow of steam in pipes (See "Mechanical Engineers Pocketbook," page 845), is,

$$\textit{Loss of pressure in pounds per square inch} = p_1 - p_2 = \frac{W^2 L}{C^2 W d^5}$$

in which W is in pounds per minute, and D, the diameter, in inches; C is an experimental coefficient. Taking L at 100 feet and C at 63.4 for the first case and 64 in the second (figures derived from Darcy's experiments on the flow of water) gives in both cases

$p_1 - p_2 = 0.029$ *pound per square inch,* or about 0.06 inch of mercury. As in modern large turbine practice L may be nearer 10 than 100 feet, this would reduce the drop in pressure to one-tenth of these figures, or to 0.006 inch of mercury, an exceedingly low figure.

It is possible that Mr. Neilson intended his formula to cover not only the loss of head (or pressure) due to friction of the pipe, but also the pressure required to cause the velocity, and also the "entry head" or the pressure required to overcome the resistance of the orifice. As the latter may be made bell-mouthed, its resistance may be neglected. If we assume that the steam in the exhaust side of the turbine has no velocity in the direction of the pipe, the velocity head may be calculated from the formula

$$h = \frac{V^2}{2g}$$

in which V is in feet per second and H, the hight, in feet of a column of steam of the given density. For the calculated velocities, 318 and 578 feet per second, h is, respectively, 1570 and 5188 feet. Reducing this to the equivalent pressure of steam occupying a volume of 350.8 cubic feet per pound gives pressures of 4.48 and 14.8 pounds per square foot, or 0.031 and 0.128 pound per square inch, respectively. These figures added to the 0.029 pound already found as the loss of pressure due to friction for a pipe 100 feet in length, gives the total loss of pressure as 0.06 and 0.157 pound, or, say, 0.12 and 0.31 inch of mercury.

As the steam leaving the vanes of the turbine must have considerable tangential velocity, with reference to the earth, and the exhaust pipe may be taken from the casing in the tangential direction, it is probable that there is no such loss of head in creating velocity as the last calculation indicates and, in that case, a material decrease in the diameter of the pipes (with consequent increase in velocity) from the diameters given by Mr. Neilson's formula might be made without any serious loss of vacuum between the condenser and the turbine, especially if the distance between them is short.

The exponent 0.4 of the factor f should be explained. According to the common formulas for flow of water, the area required for a given flow under a given head varies inversely as the square root of the mean hydraulic radius, which would make the exponent of f 0.5 instead of 0.4.

WILLIAM KENT.

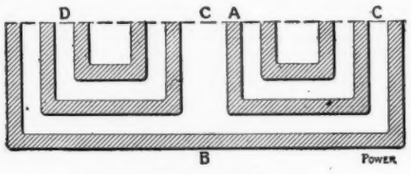
Montclair, N. J.

Mr. Stocks' Engine Valve

Regarding Allen J. Stocks' letter in the March 28 issue, I would say that he made the proper adjustments by shortening the valve rod, judging from a comparison of the diagrams in Figs. 1 and 2.

I cannot see anything wrong with the design of this valve.

Referring to the accompanying figure, which is a reproduction of part of Mr. Stocks' Fig. 3 with the reference letters added, the face A works on the face of



MR. STOCKS' VALVE

the valve seat. The face B is subjected to the steam-chest pressure, which pressure tends to hold the valve hard against the valve seat. The channels C are to allow a certain amount of steam to remain between the valve and its seat, tending to balance or resist the pressure on the face B.

It seems plain that the inventor's aim was to design a balanced slide valve without a pressure plate and his aim was in the right direction to reduce the friction and allow the automatic cutoff governor to work effectively.

The diagrams showed that the governor was handling the valve all right.

If Mr. Stocks had given a sketch of the valve seat, I might have been able to tell him more about this valve, as I think the channels D are probably meant to give the valve a double-ported effect which is common practice in the design of most automatic single slide-valve engines. The valve is made double ported to get a large port opening with a comparatively short valve travel.

Most designers know something.

W. H. MAGEE.

Brooklyn,, N. Y.

Record Breaking Turbine Test

The test performance, cited in the April 18 issue, of the 6000-kilowatt turbine unit designed by Brown, Boveri & Co., and installed in the Dunston station at Newcastle-on-Tyne, shows the best steam economy which I have seen reported, and since it was accomplished with a high degree of vacuum, the efficiency is remarkable. There are, however, certain important matters which must be considered in comparing this result with the claims and accomplishments of other large turbines of the Parsons or other types.

The machine at Newcastle is designed for a capacity of 6000 kilowatts, it operates at 1200 revolutions per minute, and in spite of this relatively low speed in proportion to its rating, the low-pressure end is arranged for double flow. The Parsons construction can be made highly efficient at the low-pressure end if space could be afforded for moderate steam velocities. The limitation of most Parsons designs lies in the fact that such space cannot be afforded and it is only in such extreme designs as the one under consideration, that the steam at the low-pressure end is not congested when operating with a good vacuum. A machine of the Curtis type operating at 1200 revolutions per minute can be proportioned with single flow for 11,000 kilowatts output without serious congestion in the low-pressure end, while the machine at the Dunston station is designed for only 6000 kilowatts and is provided with two low-pressure elements in parallel. The building of such an elaborate and expensive machine for so small an output is undoubtedly well justified by the fine results accomplished and is creditable both to the purchasers and to the designers. The practice, however, is very different from that which has been followed by many designers of Parsons turbines, particularly in this country where it is common to find single-flow machines rated at 5000 kilowatts operating at 1800 revolutions per minute, and double-flow machines rated at from 10,000 to 15,000 kilowatts operating at 1800 revolutions per minute.

I do not know how the initial cost per kilowatt of this machine would compare on an equal basis with such Parsons units as have been mentioned. It is obvious that the cost is relatively much greater and that these fine results cannot be accomplished without such increase of cost.

The machine at Dunston was built with an unusual degree of care and accuracy, it is operated continuously without variation of load, and in starting it an unprecedented length of time is expended. Under these very favorable conditions of operation it is probable that it can run with very small clearances so that the leakage losses are presumably smaller than those which are necessary in a Parsons machine run in the usual manner.

Brown, Boveri & Co. have been leaders both as to quality and quantity in the production of Parsons turbines as they have been in many other branches of engineering, and this machine represents the latest product of their experience. If other designers of Parsons turbines follow equally conservative and correct lines, they also can undoubtedly obtain equivalent results if the test reported in this case is correct. If, however, in the interest of economy they follow radically different lines, it may be presumed that they violate principles which govern quality in this art.

W. L. R. EMMET.

Schenectady, N. Y.

Preventing Power Plant Losses

The editorial in the April 4 issue of POWER under the above heading is worthy of careful attention by all progressive engineers and covers a subject that is of vital importance, not only in engineering, but in all branches of human activity.

Many are the men that have gone to the wall because of their failure to look after the little things; they take care of the large items that thrust themselves in the way but never see the small things that have to be searched for. Just as a grain of dust will stop a watch or a bolt wreck a turbine, so unseen losses will wreck a business.

With the very best of equipment and administration hardly more than 10 per cent. of the energy in coal can be realized at the switchboard. Yet, with only this small amount of power as an asset and the many and varied losses as a big debit, the engineer instead of watching such losses and trying to keep them as small as possible, lets them increase because he does not see where they go to and in addition allows a lot of unnecessary ones to creep in.

The causes that lead up to these unnecessary losses are varied, but usually come from a false sense of economy. To spend a dollar today in order to save two dollars tomorrow is unheard of.

Economy is the slogan! Buy cheap supplies! Save the dollars! The fact that the quality is as cheap as the cost is forgotten.

Pay small wages! Cheap men will make the wheels go around just the same as good men. Maybe true, but what is saved in wages is lost many times over in other ways.

Bookkeeping costs money. Cut it out. What do we care how much each item costs, as long as we know the total. Yet that is the only way in which the invisible leaks can be discovered.

All of which reminds me of a friend who walked three miles to save 5 cents carfare, and after he had gone about a mile stopped at a cigar store and spent 15 cents on cigars to keep him company the rest of the way.

W. L. DURAND.

Washington, D. C.

Pressure on Pump Plunger

In regard to B. U. Potter's inquiries in the issue of March 28, the following may be of interest to him:

In Fig. 1, let A be the position of the

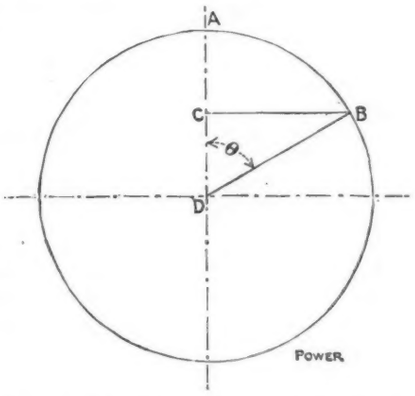


FIG. 1. DIAGRAM OF POSITION OF CRANK PIN

crank pin at top center and B the position after the crank has moved through any angle Θ. Then, AC will equal the displacement of the piston.

The displacement of the piston =

$$AD - DC$$

and

$$DC = \frac{DC}{BD} \times BD$$

or

$$DC = cos.\ \Theta \times BD$$

and

$$AC = R - (cos.\ \Theta \times R)$$

In Fig. 2 the displacement of piston No. 1 was plotted as ordinates and the degrees of revolution of crank shaft as abscissas. That of No. 2 was plotted in the same manner, but 120 degrees later, and that of No. 3 120 degrees later still. This gives the three curves as shown.

Adding the ordinates for the different positions of the crank shaft gives the line of total displacement, which is constant and equal to $3r$ or $1\frac{1}{2}$ times the displacement of one cylinder.

The angularity of the connecting rod would change the volume slightly but not enough to affect the pump.

The easiest proof of the above is to assume any position of the plungers and solve for the total displacement.

JOHN BAILEY.

Milwaukee, Wis.

Advice on Giving Advice

I have read the letter by Owen R. Owen in the March 28 number and I believe the suggestion that the editors review replies sent in by readers is a good one.

I imagine that Mr. Owen's letter will mix things up more than ever for Mr. Morris. He states that my suggestion of adding a drip at the end of the feed branch at the farthest radiator might be inconvenient. What about his idea of increasing the size of all of the pipes under certain conditions as brought up by Mr. Dixon? The drip which I suggested need only be of ½-inch pipe and need not cost very much in cash or labor.

If there is no obstruction, such as dirt of any kind (and the chances are 1000 to 1 there is no such obstruction), the drip will certainly cause the steam to circulate in the radiator.

I do not agree with Mr. Owen that it should be taken for granted that air vents are installed. The suggestions offered were based upon the description given and the sketch shown.

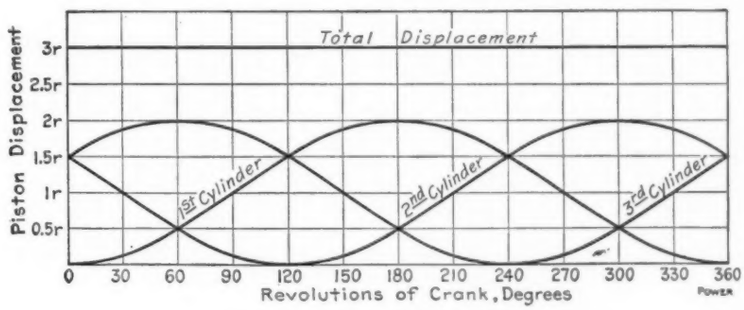


FIG. 2. DIAGRAM OF CYLINDER DISPLACEMENT

The connection which was shown by Mr. McCoffin is quite correct, but I have seen dozens of connections "bull headed," as shown in Mr. Morris' sketch, where absolutely no trouble was en-

countered; but in every case ample provision was made to carry away the condensation from the branch feed connections at the radiator end by a drip when these connections were over a few feet long.

The risers shown in the sketch (2½ inches) should be of ample size to heat any three radiators unless they are altogether larger than any generally used, and if the branch pipes are large enough (1¼ inches will supply up to 96 square feet under 5 pounds pressure with a two-pipe system) and contain no pockets, there will positively be no trouble in heating all three radiators with a one-pound steam pressure, gage, providing drips are installed.

The change suggested by Mr. Owen is all right, but it is not a sure cure; drips or bleeders are, if falls are right and all pipes are clear.

J. E. NOBLE.

Toronto, Can.

Stress in Boiler Sheets

Referring to the editorial in the February 28 issue, consider a rectangular plate as in Fig. 1, with a tension of p_1 pounds per square inch of sectional area applied in one direction and p_2 pounds per square inch of sectional area applied at right angles to the first. Let the thickness of the plate be t.

Now conceive a right-angled triangle cut from this plate as in Fig. 2. The side whose length is A is subjected to a tension of p_1 pounds per square inch of sectional area, and the side whose length is B is subjected to a tension of p_2 pounds per square inch of sectional area. The hypotenuse, whose length is C, is then subjected to a tension whose direction is perpendicular to C and whose intensity is p pounds per square inch (as yet unknown). There may also be a shearing action along C; if there is, let its intensity be S pounds per square inch.

Since t is the thickness of the plate in inches, the sectional area along the edge A is $A \times t$ square inches; hence the total force acting upon A, and perpendiuclar to it, is $A \times t \times p_1$ (Fig. 3). Similarly, the total force acting on the edge B is $B \times t \times p_2$. Acting perpendicularly to the hypotenuse is the force $C \times t \times p$, and if there is a shearing action along this edge, its total value will be $C \times t \times S$.

There must be equilibrium among these four forces. Resolving into components perpendicular to the hypotenuse,

$$C \times t \times p = A \times t \times p_1 \sin. \alpha + B \times t \times p_2 \cos. \alpha$$

and resolving parallel to the hypotenuse,

$$C \times t \times S = A \times t \times p_1 \cos. \alpha - B \times t \times p_2 \sin. \alpha$$

Dividing by $C \times t$ in both cases,

$$p = \frac{A}{C} \times \sin. \alpha \times p_1 + \frac{B}{C} \times \cos. \alpha \times p_2$$

$$S = \frac{A}{C} \times \cos. \alpha \times p_1 - \frac{B}{C} \times \sin. \alpha \times p_2$$

But $\frac{A}{C} = \sin. \alpha$, and $\frac{B}{C} = \cos. \alpha$

Hence

$$p = p_1 \sin.^2 \alpha + p_2 \cos.^2 \alpha \quad (1)$$

$$S = p_1 \sin. \alpha \times \cos. \alpha - p_2 \sin. \alpha \times \cos. \alpha = (p_1 - p_2) \sin. \alpha \times \cos. \alpha \quad (2)$$

These equations give the values of p and S under the most general circumstances. There is a shear S along the hypotenuse except when α equals zero or 90 degrees, in which case $\sin. \alpha$ and $\cos. \alpha$ are zero respectively; also in the special case where the plate is pulled equally in both directions, that is, $p_1 = p_2$, there is no shear. If p_2 be equal to p_1, equation (1) becomes

$$p = p_1 \sin.^2 \alpha + p_1 \cos.^2 \alpha = p_1 (\sin.^2 \alpha + \cos.^2 \alpha) = p_1$$

Hence, when the plate is subjected to a stress of the same intensity sidewise and endwise, the tension acting perpendicularly across any diagonal is the same in intensity.

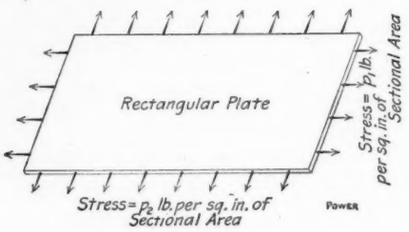


FIG. 1

Going back to the general case, in which p_1 is not equal to p_2, assume first that p_2 is greater than p_1.

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} \times \cos. 2\alpha \quad (3)$$

This expression may be verified as follows: Substituting $\cos.^2 \alpha - \sin.^2 \alpha$ for $\cos. 2\alpha$, equation (3) becomes

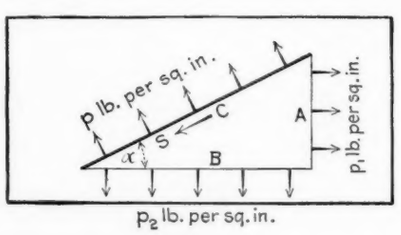


FIG. 2

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} \cdot (\cos.^2 \alpha - \sin.^2 \alpha)$$

$$= \frac{p_1}{2} + \frac{p_2}{2} + \frac{p_2}{2} \cos.^2 \alpha - \frac{p_2}{2} \sin.^2 \alpha - \frac{p_1}{2} \cos.^2 \alpha + \frac{p_1}{2} \sin.^2 \alpha$$

$$= \frac{p_1}{2} \sin.^2 \alpha + \frac{p_1}{2} (1 - \cos.^2 \alpha) + \frac{p_2}{2} \cos.^2 \alpha + \frac{p_2}{2} (1 - \sin.^2 \alpha)$$

$$= \frac{p_1}{2} \sin.^2 \alpha + \frac{p_1}{2} \sin.^2 \alpha + \frac{p_2}{2} \cos.^2 \alpha + \frac{p_2}{2} \cos.^2 \alpha$$

$$= p_1 \sin.^2 \alpha + p_2 \cos.^2 \alpha$$

which is the same as equation (1).

In the formula

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} \times \cos. 2\alpha$$

the greatest value that $\cos. 2\alpha$ can have is $+1$; hence, the greatest value p can have is

$$p = \frac{p_1 + p_2}{2} + \frac{p_2 - p_1}{2} = p_2$$

This happens only when $\cos. 2\alpha = 1$, or $\alpha = 0$. Similarly, the least value $\cos. 2\alpha$ can have is -1, which can only be when $2\alpha = 180$ degrees, or $\alpha = 90$ degrees. Then

$$p = \frac{p_1 + p_2}{2} - \frac{p_2 - p_1}{2} = p_1$$

From this it will be apparent that when p_2 and p_1 are unequal, p is always less than p_2 (the greater of the two), except when $\alpha = 0$, when it becomes equal to p_2. Similarly, p is always greater than p_1 except when $\alpha = 90$ degrees, when it becomes equal to p_1.

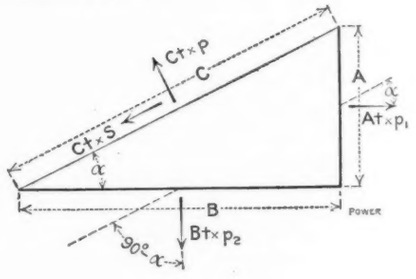


FIG. 3

As for the shear S, it may be expressed as

$$S = \tfrac{1}{2} (p_1 - p_2) 2 \times \sin. \alpha \cos. \alpha = \frac{p_1 - p_2}{2} \times \sin. 2\alpha$$

The greatest value $\sin. 2\alpha$ can have is $+1$. Hence the greatest value of S will be $\frac{p_1 - p_2}{2}$. This occurs when $\sin. 2\alpha = 1$, or $2\alpha = 90$ degrees, that is, $\alpha = 45$ degrees.

Some have been confused with the fact that the diagonal extension of a rectangular plate is greater than the extension parallel to the edges. The trouble here is, that the stress in the plate is not proportional to the absolute extension, but to the ratio that the distortion bears to the unstretched length. For example, consider a rectangle acted upon by a force of p pounds in each direction. Representing the modulus of elasticity by E_1 and referring to Fig. 4,

$$\frac{p}{E_1} = \frac{(G F)}{(F A)} \text{ along } A F$$

and

$$\frac{p}{E_1} = \frac{(B C)}{(A B)} \text{ along } A B$$

The test is not that $BC = FG$, but that $\frac{BC}{AB} = \frac{FG}{FA}$.

Let p_o be the diagonal stress. Then

$$\frac{p_o}{E_1} = \frac{DE}{AD}$$

And since,

$$\frac{DE}{AD} = \frac{BC}{AB}$$

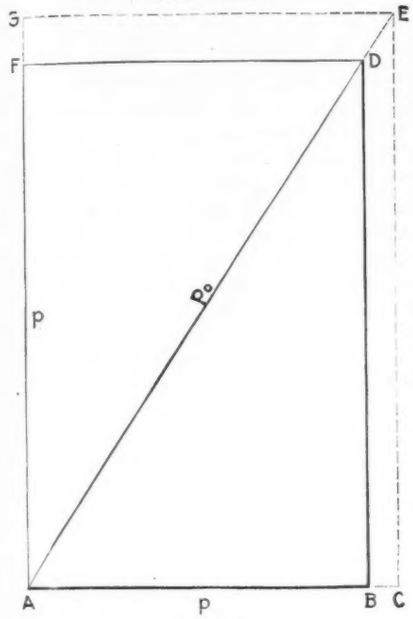


FIG. 4

it follows that

$$\frac{p_o}{E_1} = \frac{p}{E_1}, \text{ or } p_o = p$$

This is when the rectangle is stressed equally in both directions. When stressed unequally the case is more complicated.

A. D. RISTEEN.

Hartford, Conn.

The following has special reference to an editorial in the February 28 issue of POWER under the above caption:

Proposition: Through the shell of a steam boiler are there any cross-sections on which the stresses, normal or tangential, are greater than on a cross-section which contains the axis?

A discussion of this problem involves a theorem of internal stress, known as the "Ellipse of Stress." The conditions of the problem give two simple tensile stresses perpendicular to each other: one produced by the pressure on the heads, the other by the radial pressure on the shell; and in a boiler without tubes or stays, the intensity of the stress on a plane parallel to the axis is twice that on a section perpendicular to the axis.

Let Fig. 1 represent a portion of the boiler which is subject to an internal pressure p; then the stress on any horizontal plane $X\,X$, per unit of length, is $p\,r$, and the intensity of stress or the stress per square inch is $\frac{p\,r}{t}$, where r is the radius of the boiler and t the thickness of the shell.

The stress on any plane $Y\,Y$ perpendicular to the axis is $\pi\,p\,r^2$, and the stress per square inch is

$$\frac{\pi\,p\,r^2}{2\,\pi\,r\,t} = \frac{p\,r}{2\,t}$$

where $2\,\pi\,r$ is the circumference. This also proves that the intensity of stress on $X\,X$ is twice that on $Y\,Y$ as previously stated.

To determine the stresses on any plane $a\,c$ which makes an angle ϕ with the $X\,X$ plane consider the small rectangular part of the shell $a\,b\,c\,d$, and, by changing the ratio between the length of the sides, angle ϕ may have any value between 0 and 90.

Represent the unit stress acting parallel to $Y\,Y$ by p_1, and that parallel to $X\,X$ by p_2. It will simplify the solution and not change the principles if the thickness of the shell is assumed as unity; then the area of the sections $a\,b$ and $b\,c$ may be represented by $a\,b$ and $b\,c$. The total stress on $b\,c$ is $b\,c \times p_2$; this will

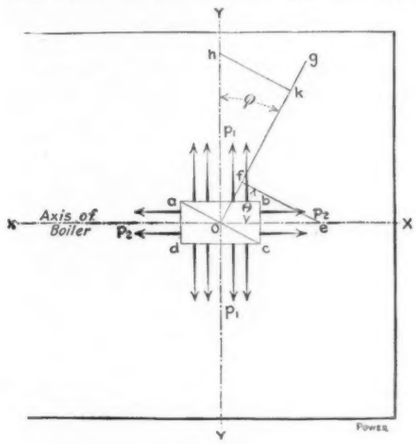


FIG. 1

be distributed over the section $a\,c$, acting obliquely thereto, the angle of obliquity being ϕ.

The area of $a\,c$ is greater than that of $b\,c$, and is equal to $\frac{bc}{sin.\,\phi}$; if the total stress $p_2 \times b\,c$ is divided by this area the unit stress is obtained, or

$$\frac{p_2 \times bc}{\frac{bc}{sin.\,\phi}} = p_2\ sin.\,\phi$$

which is the oblique unit stress on $a\,c$ due to p_2. This oblique stress may be resolved into a normal stress p_{n_2} and a shearing stress q_2. Assume $o\,e$ equal to the unit stress $p_2\ sin.\ \phi$; then $o\,f$ represents the normal stress p_{n_2}, and $f\,e$ the shearing stress q_2.

$$o\,f = o\,e\ sin.\,\phi = p_2\ sin.\,\phi\ sin.\,\phi = p_2\ sin.^2\,\phi = p_{n_2}$$

$$f\,e = o\,e\ cos.\,\phi = p_2\ sin.\,\phi\ cos.\,\phi = q_2.$$

The arrows indicate the directions in which the stresses act.

Similarly, $p_1 \times a\,b$ equals the total stress distributed over $a\,c$ due to p_1. Representing the area of $a\,c$ in terms of $a\,b$ and ϕ, area $a\,c$ equals $\frac{ab}{cos.\,\phi}$, and dividing the total stress by this area the unit stress on $a\,c$ is

$$\frac{p_1 \times ab}{\frac{ab}{cos.\,\phi}} = p_1\ cos.\,\phi$$

the line of action making an angle ϕ with the normal $o\,g$ to $a\,c$. Assume $o\,h$ equal to this unit stress $p_1\ cos.\ \phi$; then $o\,k$ is equal to the normal stress p_{n_1}, and $k\,h$ the shearing stress q_1.

$$o\,k = o\,h\ cos.\ \phi = p_1\ cos.\ \phi\ cos.\ \phi = p_1\ cos.^2\,\phi = p_{n_1}$$

$$k\,h = o\,h\ sin.\ \phi = p_1\ cos.\ \phi\ sin.\ \phi = q_1.$$

For the combined unit stresses on $a\,c$, take the algebraic sum of the stresses obtained from p_1 and p_2. Noting that the shearing stress q_2 acts opposite to q_1, the normal stress equals

$$p_{n_1} + p_{n_2} = p_1\ cos.^2\,\phi + p_2\ sin.^2\,\phi$$

and the shearing stress equals

$$p_1\ cos.\ \phi\ sin.\ \phi - p_2\ cos.\ \phi\ sin.\ \phi = (p_1 - p_2)\ sin.\ \phi\ cos.\ \phi.$$

This gives the normal and shearing unit stresses on a section making any angle ϕ with the axis of $X\,X$.

In this solution, p_1 and p_2 are both taken as tensile stresses, but generally p_1 and p_2 can be either tensile or compressive stresses; when both are tensile or compressive, the shears are of opposite sign; when one is tensile and the other compressive, the shears are of the same sign and the normals are of opposite sign.

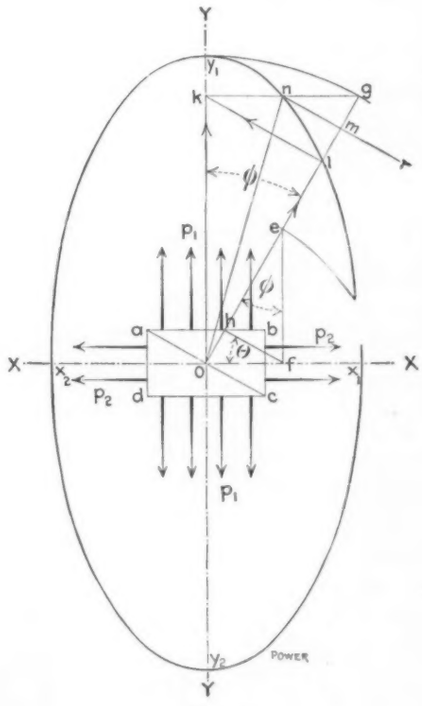


FIG. 2

In the problem under consideration, p_2 equals $\frac{1}{2}\ p_1$. Substituting this value for p_2,

$$p_{n_1} + p_{n_2} = P_n = p_1\ (cos.^2\,\phi + \tfrac{1}{2}\ sin.^2\,\phi)$$

and,

$q_1 - q_2 = Q = \frac{1}{2}\, p_1\, (sin.\, \phi\, cos.\, \phi)$.

Compounding these will give the resultant stress R equal to

$$\sqrt{P_n^2 + Q^2}$$

Next will be shown a graphical method of handling the problem. In Fig. 2, let p_1 and p_2 be the unit stresses on the faces $a\,b$ and $b\,c$. Represent these stresses by $o\,y_1$ and $o\,x_1$. All angles which are equal to ϕ and employed in the solution are marked.

On the normal $o\,g$, take $o\,e$ equal to the unit stress p_2, and draw $e\,f$ normal to $X\,X$. Then $o\,f$ equals the unit stress on $a\,c$ parallel to $X\,X$, since $o\,f$ equals $o\,e\ sin.\ \phi$. Draw the normal $f\,h$ from f to $o\,g$; then $o\,h$ will equal the normal unit stress p_{n_2} on $a\,c$ due to p_2, since

$$o\,h = o\,f\ sin.\ \phi = o\,e\ sin.^2\ \phi$$

$h\,f$ equals q_2, the shear on $a\,c$ due to p_2, since

$$h\,f = o\,f\ cos.\ \phi = o\,e\ sin.\ \phi\ cos.\ \phi$$

Similarly, take $o\,g$ equal to p_1 and draw the normal $g\,k$ to $Y\,Y$; then $o\,k$ will equal the unit stress on $a\,c$ parallel to $Y\,Y$ due to p_1, since $o\,k$ equals $o\,g\ cos.\ \phi$. Draw the normal $k\,l$ from k to $o\,g$; then $o\,l$ equals the normal unit stress p_{n_1} on $a\,c$ due to p_1, since

$$o\,l = o\,k\ cos.\ \phi = o\,g\ cos.^2\ \phi$$

and $l\,k$ equals q_1, the shear on $a\,c$ due to p_1, since

$$l\,k = o\,k\ sin.\ \phi = o\,g\ sin.\ \phi\ cos.\ \phi$$

Combining these results

$$o\,l + o\,h = o\,m, \text{ and } -h\,f + l\,k = m\,r + r\,n = m\,n$$

The line $o\,n$ represents the resultant R in direction and magnitude. The point n falls on the line $g\,k$, for the same result may be obtained by combining the unit stresses on $a\,c$ at once; $o\,k$ equals the stress parallel to $Y\,Y$ and $o\,f$ equals $k\,n$ which, in turn, equals the unit stress parallel to $X\,X$, and their resultant is $o\,n$.

The line $y_1\,n\,x\,y_2$ represents the path of the point n when both p_1 and p_2 are tensile stresses; the part below the $X\,X$ axis is the path when the same stresses are considered on the conjugate diagonal planes. If one stress is compressive, the path will be the line $y_2\,x_2\,y_1$. The complete path is an ellipse with the major and minor axis respectively p_1 and p_2. This can be readily proved as follows: The coördinates of the point n are

$$o\,k = y = p_1\ cos.\ \phi,\ k\,n = x = p_2\ \sin.\ \phi$$

$$p_2\,y = p_1\,p_2\ cos.\ \phi, \quad p_1\,x = p_1\,p_2\ sin.\ \phi$$

$$p_2^2 y^2 = p_1^2 p_2^2\ cos.^2\ \phi, \quad p_1^2 x^2 = p_1^2 p_2^2\ sin.^2\ \phi$$

$$p_1^2 x^2 + p_2^2 y^2 = p_1^2 p_2^2 (sin.^2\ \phi + cos.^2\ \phi) = p_1^2 p_2^2$$

This is the well known form of the equation of an ellipse: $b^2 x^2 + a^2 y^2 = a^2 b^2$.

The analysis of the problem shows that there are no planes of section on which the stress is greater than on the plane of section parallel to the axis; and it is evident when two simple stresses act on planes perpendicular to each other (on these planes there is no shear) that these are planes of maximum principal stress, since R, the resultant, cannot be greater than the major axis. In fact, the absence of shear on the planes shows that they are planes of maximum principal stress, for any condition of stress acting in the plane of the paper can be reduced to two sections perpendicular to each other and to the plane of the paper on which there is only simple stress, that is, no shear. If the two stresses are of the same kind they will be maximum and minimum values; if of opposite kind, both will be maximum.

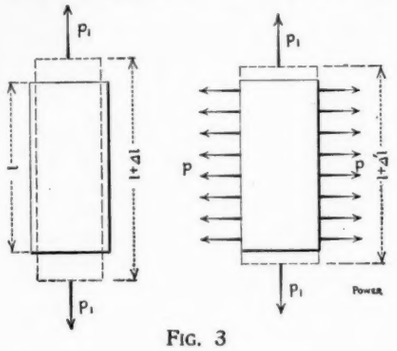


FIG. 3

As to whether the two forces acting at right angles to each other tend to raise or lower the yielding point of the material in directions parallel and perpendicular to the axis, the following extract from Greene's "Structural Mechanics," page 203, may throw light on the subject: "A plate is stronger to resist two pulls at right angles than when subjected to one only." Calculations are also made for a boiler plate subjected to a tension p_1 on a section parallel to the axis, and $\frac{1}{2}\, p_1$ on a section perpendicular to the axis, and this conclusion is arrived at: "Hence the true unit tension is less than the apparent tension by 12½ per cent., and the boiler is stronger than it would be if the longitudinal tension from the steam pressure on the heads did not exist."

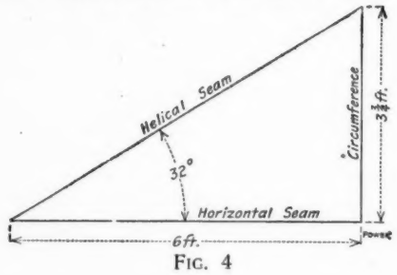


FIG. 4

Cotterill's "Applied Mechanics," page 412, states that the coefficient of elasticity E is increased in value, or, in other words, if the metal is subjected to a lateral pull, the piece will not elongate as much from the direct pull as when this lateral pull is not present.

It is difficult to see just how the unit stress can be reduced, since the stress in a body originally free from stress is caused by an external force and the unit stress is obtained by dividing this external force by the area; hence, to reduce the unit stress it would seem necessary to decrease the external force or else increase the area, and this is not done.

In Fig. 3 the left-hand sketch shows the change in shape of a rectangular piece subjected to the pull of an external force p_1; the full lines represent the shape before the force p_1 is applied and the dotted lines the shape after the force has been applied. It may be seen that when a single force p_1 acts on a bar there is a lengthening parallel to the line of action of the force, and a contraction perpendicular thereto. The unit stress on a right section is p_1 divided by the area.

In the right-hand sketch the piece is subjected to a lateral force p, the intensity of which is such that no contraction takes place when the force p_1 is applied. Here the elongation will be less than in the first case. The unit stress will be p_1 divided by the area as before.

In the left-hand sketch the length after the force p_1 has been applied is $(l + \Delta\, l)$, where l is the original length and $\Delta\, l$ is the increase per unit length. In the right-hand sketch the length will be $(l + \Delta' l)$, where $\Delta' l$ is less than $\Delta\, l$. Where E and E' represent the coefficients of elasticity,

$$E = \frac{p_1}{\Delta\, l} \text{ and } E' = \frac{p_1}{\Delta' l}$$

Hence E in the first case is less than E' in the second case. The conclusion that E is less than E' may be arrived at by considering the unit stress on a cross-section the same in both cases; and the conclusion that the stress on a cross-section is decreased may be arrived at by considering that E', the coefficient of elasticity, does not change.

From what has been written on the subject it appears safe to assume that the two stresses at right angles do not, on any plane, subject the shell to a stress greater than that on the longitudinal plane, and it is possible that the material may be able to resist a greater pull when subjected to a lateral stress than when not, due to the fact that it will take a greater force to produce the same elongation and not any decrease in the unit stress.

This problem suggests a way in which the weakness of the shell due to the riveted joint may be overcome. Assume, for example, a boiler with a triple-riveted butt joint having an efficiency of 85 per cent. If this joint coincides with a plane on which the resultant stress R is less than 85 per cent. of the stress on a plane parallel to the axis, the joint will be stronger to resist the bursting pressure than the shell itself. Proceed to

locate this plane when p_2 equals $\frac{1}{2}\ p_1$. Noting that the resultant

$$R = \sqrt{p_1^2\ cos.^2\ \phi + p_2^2\ sin.^2\ \phi}$$

and that R equals 85 per cent. of p_1,

$$(0.85\ p_1)^2 = p_1^2\ cos.^2\ \phi + \tfrac{1}{4}\ p_1^2\ sin.^2\ \phi$$

$$(0.85)^2 \times 4 = 4\ cos.^2\ \phi + 1 - cos.^2\ \phi = 3\ cos.^2\ \phi + 1$$

$$1.89 = 3\ cos.^2\ \phi,\ \phi = 37\tfrac{1}{2}\ degrees$$

From this it will be seen that if the seam made an angle of 37½ degrees with the axis, the seam would be as strong as the

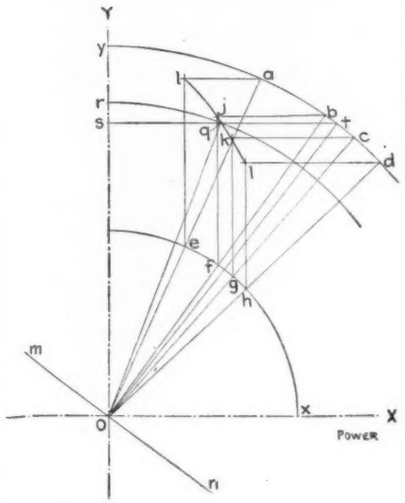


FIG. 5

shell to resist the stresses acting, and this on the assumption that p_2 equals $\frac{1}{2}\ p_1$, which, generally, in a steam boiler is not true, due to the tubes and bracing.

Consider a horizontal tubular boiler 72 inches in diameter and with through braces. If it is assumed that the shell carries the pressure on the heads which fall within 6 inches of the shell, the error will be on the safe side. This gives as the total stress on the shell when p is the pressure per square inch

$$p\ (36^2\ \pi - 30^2\ \pi) = 1244\ p$$

Dividing by the circumference,

$$\frac{1244}{226}\ p = approximately\ 5\tfrac{1}{2}\ p$$

as the stress per lineal inch on a section perpendicular to the axis. The stress per lineal inch in the shell due to the radial pressure is 36 p. From this is obtained the ratio,

$$\frac{p_1}{p_2} = \frac{36\ p}{5\frac{1}{2}\ p} = \frac{36}{5\frac{1}{2}}$$

and

$$p_1 = 6.5\ p_2,\ \text{or}\ p_2 = \frac{2}{13}\ p_1$$

Solving the problem on this basis,

$$(0.85\ p_1)^2 = p_1^2\ cos.^2\ \phi + \frac{4}{169}\ p_1^2\ sin.^2\ \phi$$

whence

$$cos.^2\ \phi = 0.846 \text{ and } \phi = 32\ degrees$$

If the sheet be 6 feet wide, the seam will extend around the shell (see Fig. 4)

$$6 \times tan.\ 32\ degrees = 6 \times 0.625 = 3.75\ feet$$

It seems that this should not be a serious difficulty, practically, when it is considered that a quadruple-riveted butt joint is used to increase the efficiency of joint to about 92 per cent., while this construction makes it as strong as the shell.

I also add an easy graphical method of locating the required plane (see Fig. 5). Take p_1 equal to $o\ y$ on the Y-axis; p_2 equal to $o\ x$ on the X-axis; and $o\ r$ equal to the resultant R. Draw arcs of circles with these distances as radii. Through these circles draw the radial lines $o\ a$, $o\ b$, $o\ c$ and $o\ d$, and from the points where these lines cut the circles locate the points i, j, k and l, of the ellipse as shown. A line drawn from o to the point where the ellipse cuts the circle of radius r is the resultant, and a line drawn through this point parallel to the X-axis cuts the large circle of radius p_1 at the point t; $o\ t$ is normal to the plane $m\ n$ on which R is the resultant stress; hence, $m\ n$ is the required location of the seam.

Bradford, Penn. JAMES CLARK.

The editorial under the above caption in the February 28 issue set me to thinking, and I worked out the following:

Laying out a force diagram, as in Fig. 1, with two units of force acting in one direction and one unit of force acting at right angles to the first, the resultant force acts along the hypotenuse and equals 2.23607 units of force.

A piece of boiler plate one inch square is so nearly flat that it may be considered as such, and if twice the stress be applied in one direction as is applied in a direction at right angles it will represent the conditions to which the shell of a

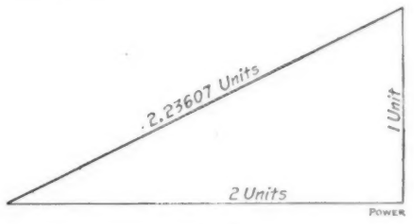


FIG. 1

boiler is subjected, so far as pressure is is concerned. Up to the elastic limit the change of length will be proportional to the stress.

Let the two units of force representing the circumferential stress lengthen this side 0.2 inch, and with one unit applied to the other side it will be lengthened 0.1 inch; this represents the girth stress. The square will then have changed to a parallelogram having sides respectively 1.2 and 1.1 inches.

Laying out a second force diagram, as in Fig. 2, the line of the resultant force is found to extend from the lower left-hand corner to a point half way up the short side. This force, as in Fig. 1, equals 2.23607 units, but it is resisted by the metal along a line at right angles to its line of action, that is, along line $A\ B$.

$$Tan.\ d\ c\ b = \tfrac{1}{2}$$

$$Angle\ d\ c\ b = 26\ degrees\ 33\ minutes\ 53.5\ seconds$$

$$Angle\ a\ c\ d = 90\ degrees - 26\ degrees\ 33\ minutes\ 53.5\ seconds = 63\ degrees\ 26\ minutes\ 6.5\ seconds$$

$$Line\ a\ d = sin.\ a\ c\ d \times 1 = 0.89442$$

$$Line\ c\ d = cos.\ a\ c\ d \times 1 = 0.44727$$

$$Line\ d\ b = tan.\ d\ c\ b \times c\ d = \tfrac{1}{2} \times 0.44727 = 0.223635$$

$$Line\ a\ b = a\ d + d\ b = 0.89442 + 0.223635 = 1.118055$$

Hence

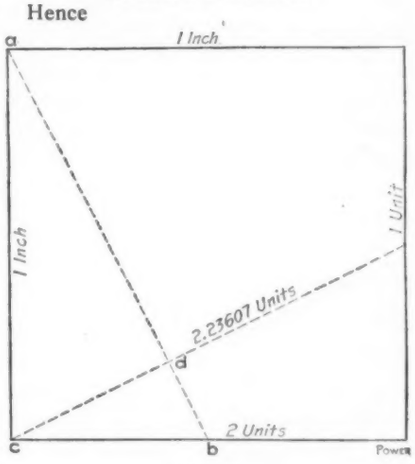


FIG. 2

$$\frac{2.23607}{1.118055} = 1.9999\ units$$

per inch width of metal in the direction of the resultant force.

The cosine of angle $d\ c\ b$ equals 0.89442, and the length of the line along which the resultant force acts is

$$\frac{1}{0.89442} = 1.118\ inches$$

before the force is applied.

If one unit of force will lengthen an inch of the metal 0.1 inch, 1.9999 units will lengthen the line of the resultant force

$$1.118 \times \frac{1.9999}{10} = 0.2236\ inch$$

which added to the original length equals,

$$1.118 + 0.2236 = 1.3416\ inches$$

If the long side of the plate be divided by the cosine of angle $d\ c\ b$ the result will be

$$\frac{1.2}{0.89442} = 1.3416\ inches$$

which was previously obtained.

I believe that this shows that the greatest strain is along the longitudinal line. Of course, the deformations here assumed are greater than an actual boiler plate would be subjected to, but the proportions will remain the same.

L. A. FITTS.

West Fitchburg, Mass.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Small Filter Tank

I have a large wood tank which I wish to convert into a filter for boiler-feed water. Please tell me how to do it correctly.

S. F. T.

Across one part of the tank, near the bottom, a loose floor of slats should be laid. On this floor put a layer of burlap, excelsior or gravel, and cover with coarse sand. Let the water in on top of the sand at one end and pump from the bottom of the tank at the other.

Valve Setting on Armington & Sims Engine

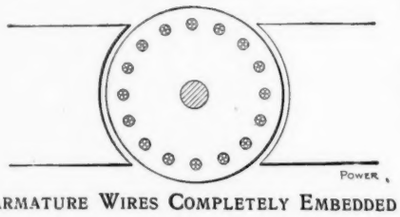
How can I set the valves on a cross compound-condensing Armington & Sims engine? Also, how can I prevent the engine from running away when working condensing and the load is suddenly released?

W. J. P.

The Armington & Sims engine belongs to the class in which the valve setting is by lead. All that the engineer can do is to keep the valve stem of such a length that the lead will be approximately equal at both ends. In this engine the lead is constant for all points of cutoff, and it is possible that with a condenser steam enough may be admitted through lead to run the engine above a safe speed without load. If such is the case a separate speed-limit or safety-stop appliance is the only remedy.

Completely Embedded Armature Wires

If the wires of an armature winding were threaded through holes some distance from the edge of the core, as shown in my sketch, would the armature generate any electromotive force when revolved between field-magnet poles, as in an ordinary dynamo?



ARMATURE WIRES COMPLETELY EMBEDDED

W. C. T.

Yes; but not quite as much as though open slots were used, as in the usual form of armature. Some of the magnetic lines would pass from pole to pole through the narrow strip of core metal between the holes and the periphery without affecting the armature conductors at all, but a large proportion would have to pass to the inner part of the core because the annular strip around the edge would not carry all of them. Those that pass to the inner core body would generate an electromotive force in the wires.

Cause of Knocking

At times my engine has a peculiar knock. If I feed a lot of oil the sound is reduced but not entirely removed. Can you tell me the cause of the knock and the remedy?

G. B. S.

It is doubtful if a lack of oil will cause knocking. Insufficient lubrication will cause harsh grinding noises, but not knocks. It sometimes happens that the piston ring has "play" in its groove, which will result in a knocking that is difficult to locate and a flood of oil will reduce the sound by partially filling the waste space and reducing the lost motion. The remedy in such a case is a new ring properly fitted.

Water Meter in Feed Pipe Line

I am about to install a water meter on my feed line to the heater. The supply pipe is two inches. I have been told that a 1-inch meter will be of ample size to deliver all my water; but I want to know whether the pressure on the discharge side of the meter will be reduced or whether an increased velocity through the meter will hold the pressure.

W. J. M.

The reduction in pressure on the discharge side of the meter in the feed line will be only that required to overcome the friction of the meter and is negligible.

If the demand for feed water requires the use of a 2-inch pipe, a meter with 2-inch connections should be installed, as one with 1-inch connections will require a velocity of flow through the meter four times as great as that for which it was designed.

Blow Back in Crane Safety Valve

Can the amount of blow back in the Crane Company's pop safety valve be changed by dismantling the valve and changing the tension of the auxiliary spring?

L. B. R.

The blow back in the Crane pop safety valve depends on the tension of the auxiliary spring, which is adjusted at the factory. If there were no tension at all on the spring, the disk which forms the huddling chamber would slide up the stem whenever the valve opened, and there would be no blow back at all. If the tension of this spring were made equal to or greater in proportion to the area of the huddling chamber than that of the mainspring, the blow back would depend on the area of the huddling-chamber disk. Hence, at any tension between zero and that of the mainspring, the blow back will depend on the auxiliary spring, and may be adjusted or altered by increasing or diminishing its tension.

The Six-stroke Cycle

What are the successive strokes in the six-stroke gas-engine cycle?

L. A. B.

(1) Mixture intake; (2) compression; (3) expansion; (4) expulsion or exhaust; (5) intake of air alone; (6) scavenging, driving out the air just taken in, together with a large part of the burned gases from the previous combustion.

Compounding and Overcompounding

What is the difference between a compound-wound and an overcompound-wound dynamo?

E. R. K.

A "flat"-compounded dynamo gives exactly the same voltage at its terminals at full load that it does at no load. An overcompounded dynamo gives a higher voltage at its terminals at full load than at no load. The difference is produced either by proportioning the series field winding differently or by the adjustment of a resistance strip in parallel with the series field winding, commonly called a "shunt" strip. Read the "Primer of Electricity" in the January 10 and February 21 numbers.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 32,000 *copies are printed.*

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

Contents

PAGE

Municipal Pumping and Power Plant 716
High Boiler Efficiency with Oil Fuel. 720
The Cooling of Circulating Water.. 724
Bonom Steam Turbine..... 726
The Value of the CO_2 Recorder..... 728
The Care and Operation of Storage Batteries 730
Water Tank Signal Systems..... 733
Making an Engine Lift Itself to the Foundation 734
Development of the Gasolene Engine 734
An Inconsistent Engine..... 735
Corrosion of Water Cooled Exhaust Pipes 735
Practical Letters:
Isolated Power Plant Makes a Good Showing....Crank Pin Repairs....Changing Shifts....Condensing Apparatus....Lubricating the Bell Crank....Improved Engineering Conditions ....Novel Boiler Construction ....Standpipe on Heating System 736-738
Discussion Letters:
Specialists....Size of Turbine Exhaust Pipes....Mr. Stocks' Engine Valve....Record Breaking Turbine Test....Preventing Power Plant Losses....Pressure on Pump Plunger....Advice on Giving Advice....Stress in Boiler Sheets.....739-745
Editorials 747-748

POWER

The Alaskan Coalfields

The *Philadelphia North American* is authority for some disclosures regarding the Alaskan coalfields which should make the conservationists sit up and take notice.

According to this report it appears that on October 28, eleven days before the last election and several months after the attempt to turn over the Alaskan coalfields to the Morgan-Guggenheim interests had been frustrated by public sentiment, President Taft himself gave actual control of the coalfields to this same syndicate.

In the Ballinger investigation the fact was brought out that the claimants to these coalfields, which had been thrown open to public entry, had signed an agreement with the Morgan-Guggenheim syndicate by which a half interest in the property was to pass to the latter. Furthermore, all coal was to be sold at a fixed price to the syndicate, which was already building a railroad to the fields from Cordova bay, and any further sale to consumers was to be made by the syndicate. The unexpected opposition which developed against turning over these public lands to claimants who were no more than representatives of the Morgan-Guggenheim interests, made the outcome of the scheme somewhat doubtful. Hence, the syndicate began to look about for other outlets, from the mines to the sea, than those already under its control.

There remained just one other outlet to a natural harbor (Controller bay) and this lay in the Government forest reserve and was thus protected against private interests. The President, however, signed an order withdrawing this strip of land from the reserve and throwing it open to public entry. It appears that this order was not made public until a short time ago and it is charged that during the intervening time representatives of the Morgan-Guggenheim interests have taken up claims upon the land and have thus secured for the syndicate absolute control of the only possible outlet from the mines to tidewater, not already under their control.

To the general public, the motives underlying the President's actions in this case must remain more or less a matter of conjecture. He may have been the victim of misrepresentation, or he may have taken the stand that these coalfields should be developed as soon as possible and that only a concern of such magnitude as the Morgan-Guggenheim syndicate would be in a position to effectively carry out the development. Whatever the motives, the action was untimely in view of the pending investigations and the public attitude regarding conservation, and the preservation to the people of their interest in the country's natural resources.

Firing Boiler Furnaces

Various articles have been published giving advice as to the best method to pursue to get better results in the boiler room.

It is well known that the principal losses are due to poor firing, improper working of the stokers, where used, excessive air admitted to the furnace and improper furnace design. Then there are scaly boilers, steam pipes radiating heat, and leaky joints and valves.

It is within the province of every engineer to eliminate to a great extent these sources of loss, if he goes about it in the right way. Doubtless the problem of getting the firemen to handle their fires properly is the most difficult one that the engineer has to solve.

How often should the firemen fire the boilers? How much coal should they put in the furnace at one firing, and how thick a fire should be carried? It has been urged that the greatest economy is obtained when the least amount of fuel is put into a furnace at any one time that will maintain a constant steam pressure. Throwing in from ten to fifteen shovelfuls of coal at one firing is wasteful and should not be countenanced.

Some engineers contend that a thin fire is the better; others that a thick fire gives better results, and still others that a medium fire is the most desirable.

Doubtless the advocates for each thickness of fire have good and valid reasons for preferring one method over the other, but how have they arrived at the conclusion that their methods are the best and most economical?

In a certain plant in a manufacturing city, the firemen fire at a given signal, slice the fires at another signal, and level at a third signal and good results are said to be obtained. In another plant the firemen fire when they think the fires require a new charge of fuel; in fact, they use their own judgment as to

the way the fires ought to be handled and, although an exceedingly thick fire is carried, the plant is said by those who are in a position to know to be one of the most economically operated plants in the New England States.

Why should two steam plants, operated under such radically different lines, give the good results that are claimed for them?

It would seem that there is more to this firing problem than has been determined. It would also seem that it is not a safe thing for an engineer to follow one method of firing just because someone else has been obtaining good results. A better way would be to carry on experiments with various methods of firing to find out just what method is the most economical for any particular plant. If a thin fire and frequent firing are best, use this method; if heavy firing and a thick fire give better results, use that method. It is not the way coal is fired that counts; it is the economical results obtained from the burning fuel that are of real importance.

Who Is Responsible

If the news items sometimes seen in the daily press are a criterion of the intelligence of the men who are often entrusted with the care of steam-power machinery, the efforts of the advocates for engineers' license laws should also cover the field of watchmen and wipers.

It is recorded that "a watchman in the employ of the Diamond Sand and Gravel Company, of Bedford, O., was severly scalded while attempting to make some slight repairs to a safety valve." How he discovered that repairs were necessary or on whose authority he started the work does not appear. There was pressure on the boiler, so he drew the fire, climbed to the top of the boiler and with a large monkey wrench started to unscrew the valve from the boiler. While doing this the valve opened, the discharge striking him fair in the face, scalding him badly and probably destroying his sight.

It is a pitiful story. A young man blinded and disfigured for life because someone blundered. But who? Was it the man himself or the one who made him a watchman? Why should a watchman in a State full of licensed engineers meddle with a safety valve whether on or off a boiler?

Did he think that the steam pressure would cease as soon as the fire was drawn?

Every few days someone is killed or injured because someone else did not know that the gun was loaded. But everybody knows that the steam boiler is loaded. Yet accidents both painful and fatal are of daily occurrence because the simplest of natural laws are recklessly violated.

In one State a boiler explodes because the man in charge screws down on the safety-valve spring and in another because the stop valve is opened too suddenly. Who is responsible for such blunders, the man who knows no better or his employer?

The paths of progress in all lines are marked by martyrs and perhaps the human race will not be slower to learn at the costly school of experience than are the lower animals. It is to be hoped not.

Machine-Made Engineers

There seems to be an impression permeating some quarters that the Institute of Operating Engineers is to be used for the purpose of turning out a supply of "machine made" engineers to compete with and displace the homemade variety now operating most of the power plants.

Nothing could be further from the truth. The primary idea of the Institute is to direct intelligently the education of the present engineer, and of the power-plant worker who desires to become one. Far from bearing the "machine made" earmarks of mediocrity, each individual will be advanced in his standing in the Institute as he demonstrates his fitness for advancement.

The Institute has nothing to offer to the contented worker but everything to the one who, possessed by an intelligent dissatisfaction with his present position and attainments, is willing to earn preferment.

To the engineer who recognizes the fact that he owes to himself as well as to society the duty of making the most of his opportunities for mental and manual training the Institute will be an ever welcome guide and help. But there is no room on its membership roll for the names of those who are satisfied to continue as manual workers for wages alone.

Comparative Steam Turbine Performances

Upon page 595 of the April 18 issue was given a comparison of results obtained with Curtis turbines as built by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and the General Electric Company, of Schenectady. While the steam actually used is less for the German turbine, 11.9 and 11.97 pounds per kilowatt-hour against 12.9 and 13 for the American, the German turbine was tested with a much higher degree of superheat, and in the later test with a better vacuum. The pressure was about the same in all four tests, from 188 to 195 pounds, but the temperature in the German tests was 601 and 630 against 525 and 505 degrees, giving the German turbine 256 and 285 degrees against 95 and 125.1 for the American. Here is a difference of 160 degrees of superheat and the experience of the General Electric Company has been that the performance of its turbine is improved one per cent. for about 12.5 degrees of superheat. The performance of the German turbine in question with the higher degree of superheat is only about eight per cent. better than the American with 160 degrees less which ought to improve its performance about 13 per cent.; and the German turbine had a somewhat better vacuum.

The American turbine was designed for the conditions under which it ran and converted 66.2 per cent. of the heat available by the Rankine cycle, while the German turbine converted only 63.6 of the available heat under the conditions of its test.

The use of high degrees of superheat is not common in America, and it is hardly fair to compare water rates obtained under conditions involving greater possibilities with those obtained here under less favorable conditions.

Investors in water-power development want to know what the Government will do with their property at the end of a limited franchise.

Self-respect and a definite knowledge of one's ability are requisite to complete success in engineering or anything else. But self-inflation and the unproved assumption that you are just as capable as any other man are fatal, especially in power-plant work.

Because it is sold as "carbonless antifriction unchangeable cylinder lubricant," some men will unquestioningly torture the cylinder of a gas engine with stuff that is about as healthy for it as axle grease would be for a watch.

An average boiler efficiency of 80.47 per cent. is unusually high. This was obtained at the Redondo plant of the Pacific Light and Power Company, using crude oil as fuel.

Where a cooling tower is used a moderate vacuum under some conditions is preferable to a high vacuum.

In the power-plant field there are specialists in all branches of the trade—even brake specialists. See page 723 of this issue.

The season of refrigeration is now at hand and our new department will be right in line. Good practical articles on the operation of refrigerating machinery and special kinks installed in your plant is the kind of material needed to make this department a success. We are depending on our readers to come to the front.

It is one thing to know how to play a scientific game of pool and another to run a power plant; the pool game will not give many pointers.

Government Water Power Developments

In the power field there is no question of more pressing importance than Government control and development of water power. The recent discussion before the National Electric Light Association brought out some interesting points on the subject. It is high time for the Government to get busy and establish some definite policy. On this same general question an interesting editorial on water powers was recently published in the *Engineering Record* and is reproduced in the following paragraphs:

The utilization of water power in Sweden at the present time has an aspect which deserves to be investigated carefully and the details put on record for the benefit of those interested in the rational development of our own water powers. New York State has an area only one-fourth that of Sweden, but its population is almost twice as great. Although its resources, per capita or per square mile of territory, are much greater than those of the Scandinavian kingdom, and, although a State Water Supply Commission has made an analysis of its water-power possibilities which points with the utmost clearness to the desirability of developing these resources under some system of State control and aid, nothing has been done along these lines but to talk. As a result, the choicest power sites in the State are being developed quite quickly by companies and, if legislation is not more rapid than hitherto, the people of the State will shortly find that any rational utilization will be extremely costly, owing to the rights that are now being secured so diligently and unobtrusively by private parties. No one can read the reports of the New York Water Supply Commission and the monograph on hydraulic-power development written by M. O. Leighton for the United States Geological Survey without being thoroughly convinced that State control and State aid in this work are desirable theoretically and very necessary practically.

In Sweden the early hydraulic-power development was done by the private companies and there are many of them in that country. A study of the water resources of the State showed, however, that a large amount of power was not being utilized by these companies which could nevertheless be developed and sold on a profitable basis. Coal is expensive in Sweden and power developed at hydroelectric plants has a wider range of commercial value than is the case where fuel is less costly. The government has undertaken the construction of hydroelectric plants which it proposes to run as revenue-producing establishments, if possible, and in any case in such a way as to meet all charges. The government works now under construction at the Trollhättan and Porjus falls have been described in numerous electrical publications and these will be ready for service before long. Their manifest success has led to the development of a third project, at Alfkarleby falls on the Dala river, which it is believed will receive the approval of the legislature. Some figures recently published in *Engineering* show that within 65 miles of the power station there is a probable consumption of nearly 15,000 kilowatts, which will call for development of about 22,000 hydraulic water power. If the uses of electricity are still further extended the plant can be increased to a capacity of 45,000 horsepower. The initial installation will cost something like $125 per horsepower, but the total cost of the final installation of 45,000 horsepower will be at the rate of $55 per horsepower. These figures are only approximate, for the information at hand does not indicate how much reserve capacity is included, although it is understood that there is a reserve and that the rating of the station is that for continuous operation.

The technical details of these government plants are decidedly interesting, but they are subordinated by the important economic principles involved in their construction. The Swedish government sends engineers to this country to report on what is being done in the way of developing water power in the United States. It is highly desirable for our Government or for one of the States to send representatives to Sweden in order to find out just what that enterprising kingdom is doing. It is certainly showing more sense in dealing with hydraulic power than we are.

A Busy Day at the Plant

By A. E. Dixon

Of course, you know things happen in bunches. Well, we got ours the other day. First round was called off in the smiths' shop, where the boss told one of the "Hunkies" to liven up a fire a bit. Well, he just selected the wrong Hunkie, and one who happened to know the location of a loose five-gallon can of benzine. Mr. Hunkie sure did liven that fire some. The boss got his share of it, or rather more than his share, while the Hunkie got his hands burnt. Better luck than management.

The next episode was trying to put a belt on. This was called off before we'd got quite quieted down from the explosion. The machine hand had seen that belt put on a dozen times and so he concluded he'd put 'er on. Well, he sure was a lucky boy; his overalls was old, but he was one scared kid and will leave the putting on of belts to the right man hereafter. He climbed the ladder and got the belt on, but he got the skirt of his overall jacket in the belt and a single yank took it off him. The cloth was rotten from alkali and tore easy or Johnny would have gone over the shaft and into the ambulance. He was so scared he could not get down the ladder.

Mechanical Engineers at Pittsburg

The application of mechanical engineering to the field of cement manufacture will be one of the important questions considered by the American Society of Mechanical Engineers at their annual spring meeting, to be held in Pittsburg, Penn., May 30 to June 2. Papers will be presented covering different phases of the subject.

In addition to papers dealing with machine-shop practice, there will be papers on the "Commercial Application of the Turbine Turbo-Compressor," by R. H. Rice, of the General Electric Company, West Lynn, Mass.; and upon "Hydraulic Forging Pressers and Blowing Engines"; and on miscellaneous topics, including papers on "Stresses in Tubes," by Reid T. Stewart, professor of mechanical engineering of the University of Pittsburg; the "Purchase of Coal on the Heat Unit Basis," by Dwight T. Randall, engineer in charge of the fuel-engineering department of Arthur T. Little, Incorporated, Boston, Mass.; "Energy and Pressure Drop in Compound Steam Engines," by F. E. Cardullo, of the department of mechanical engineering of the New Hampshire College of Agriculture and the Mechanic Arts; and "A Pressure Recording Indicator for Punching Machinery," by Gardner C. Anthony, dean of the engineering school of Tufts College. There will also be a session on gas power, with papers to be announced.

The convention will open on Tuesday afternoon, May 30, with the registration and reunion of members at the headquarters in the Hotel Schenley, followed by an informal reception for members and guests on the evening of the same day. There will also be an opportunity on Tuesday and Wednesday afternoons for inspection of the Foundry and Machine Exhibition Company's exhibit, which will be in progress in the exhibition building. On Wednesday morning, "The Mechanical Engineering of Cement Manufacture" will be the subject of the first of the technical sessions, all of which will be held in Carnegie Institute, in close proximity to the society's headquarters. In the afternoon a trip to the works of the Universal Portland Cement Company will be made, with a stop at East Pittsburg to allow those who desire to visit the plants of the Westinghouse Electric and Manufacturing Company and the Westinghouse Machine Company. The second technical session, at which the papers on "Machine Shop Practice" will be presented, is scheduled for the evening of the same day. The

professional session of Thursday morning will deal with miscellaneous topics and will be as brief as possible, in order to leave ample time for an excursion up the Monongahela river, including a visit to the National Tube Company's works at McKeesport. A reception and informal dance will take place in the evening at the convention headquarters. The concluding professional session, at which "Steel Works Practice" will be the subject for consideration, will take place on Friday morning. An inspection trip to the Mesta Machine Company's works at Homestead, Penn., is planned for the afternoon of Friday, and the convention will close that evening with a smoker and entertainment given by the Engineers' Society of Western Pennsylvania at their rooms in the Oliver building. A ladies' committee, Mrs. Chester B. Albree, chairman, will care for the pleasure of the guests of the society and will, as is usual at these conventions, do much to add to the social features of the occasion.

N. A. S. E. State Conventions

The following is a list of the annual conventions of the various State associations, giving the place of meeting and the date for each State in alphabetical order:

California...San Francisco...June 5-10
Colorado.....Pueblo.....June 9, 10
Connecticut....Hartford....June 23, 24
Illinois.....Ottawa.....May 19, 20
Indiana.....Terre Haute.....June 9, 10
Iowa.....Ottumwa.....May 25-27
Kentucky.....Louisville.....June 2, 3
Massachusetts...Worcester...July 14, 15
Michigan.....Saginaw.....July 21, 22
Minnesota....St. Paul....August 23-26
Missouri....Kansas City....July 12-14
New Jersey.....Newark.....June 3-5
New York.....Albany.....June 9, 10
Ohio....Cincinnati....September 11, 12
Pennsylvania....Johnstown....June 2, 3
Texas.....San Antonio.....
West Virginia...Clarksburg.....
Wisconsin.....Milwaukee.....June 8-11

SOCIETY NOTES

At the second annual meeting of the American Institute of Steam Boiler Inspectors, held at the Parker house, Boston, the following officers were elected for the ensuing year: President, J. F. Molloy; vice-president, A. D. Evans; treasurer, Adam Oldfield; secretary, T. G. Ranton, 112 Water street, Boston; executive committee, E. R. Doherty, M. S. King, E. J. Scanlan, H. Van Ormer and R. L. Hemingway.

The tentative program of the coming convention of the National Electric Light Association, May 30 to June 2, provides for two sessions daily for four days and over sixteen sessions in all, there being several parallel sessions. There are twenty-four papers in the program and nearly forty committee reports. In all there are some seventy items in the order of business and it will take the full time of the convention to dispose of them.

Detroit is planning for the convention of the National Gas and Gasolene Engine Trades Association meeting of June 20 to 23, inclusive. President C. O. Hamilton is planning a convention that will consist of snappy sessions, comparatively short in length, with plenty of opportunities for discussions, seeing of the exhibits, viewing the many civic and commercial attractions of Detroit and leaving time for much in the way of entertainment. Exhibit space will be provided without charge for any light articles which can be shown without damage to woodwork or floors of the Hotel Pontchartrain, where the convention will be held.

The third international congress of refrigeration will be held in the United States in 1913 under the auspices of the American Association of Refrigeration. The second international congress was held at Vienna in October of 1910. Theodore O. Vilter, of Milwaukee, who represented the American association at the Vienna congress, who was active in obtaining the third congress for America and who is now the president of the American association, has isued an urgent appeal for members and contributions to an extent which will allow the American association to provide a reception and entertainment which will compare with that which was accorded to the congress at Vienna.

PERSONAL

A. H. Foster, formerly with the Clement Restein Company, has recently changed his position and is now connected with the Henry Johnson Packing Company, of Jersey City.

Henry R. Cobleigh has resigned as mechanical editor of *The Iron Age,* which position he has held for the last seven years, to take charge of the advertising and publicity of the International Steam Pump Company, 115 Broadway, New York City. He entered upon his new duties May 1.

Percival Robert Moses, consulting engineer, 366 Fifth avenue, New York City, announces that he has associated with him the following engineers as permanent additions to his staff: John Fallon, industrial engineer, recently mechanical engineer of the Tennessee Copper Company, and Stanley G. Flagg & Co.; Arthur V. Farr, textile engineer, formerly Szepesi & Farr, 90 West street; Alphonse Kaufman, formerly manager and chief engineer of the Alaska Chemical Company, and associated with Charles B. Jacobs industrial laboratories; J. N. Walton, recently power engineer and storage-battery expert of the Brooklyn Edison Company. The office is prepared to handle complete industrial equipments.

BUSINESS ITEMS

The Rateau turbine, which has been heretofore built in this country by the Bail & Wood Company, is now manufactured by the Southwark Foundry and Machine Company, Philadelphia. The company already has under construction some large turbine-driven centrifugal blowers for steel-works service.

Beginning May 1 the Bundy steam trap, which has always been manufactured by the Nashua Machine Company, Nashua, N. H., and marketed through selling arrangements, formerly with the A. A. Griffing Iron Company, and later through the American Radiator Company, will be sold through the selling department of the Nashua Machine Company, located at 127 Federal street, Boston, Mass. The sales manager will be John Sabin, who was the first man to introduce a tilting trap on the market over twenty years ago and who has been closely associated with the Bundy trap ever since.

A book which should prove very attractive to engineers has just been issued by the George M. Newhall Engineering Company, of Philadelphia, manufacturer of the Vance steam trap. The book is called the "Engineers' Reference Book," and is more than half composed of valuable information for the engineer, gleaned mostly from Kent's "Mechanical Engineers Pocket Book." There are between 50 and 100 subjects reprinted from Kent's alone, embracing information which the engineer has almost daily need for. It will be sent to anyone requesting a copy, and is partly devoted to a discussion and comparison of the different types of steam traps; a large portion of which is regarding steam-trap capacities. A very original and practical method is given for determining what capacity of traps are required under all different conditions. The book also contains complete description of the Vance steam trap. Anyone desiring a copy can obtain one without cost from George M. Newhall Engineering Company, 136 South Fourth street, Philadelphia, Penn.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Experienced foreman engineer for sugar refinery; credentials required. Apply P. O. Box 1660, Vancouver, B. C.

ENGINEERS WANTED to solicit for the Rolin patent adjustable grate. Apply Standard Grate Co., Heed Bldg., Philadelphia.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

SALESMAN calling at power plants to handle as a side line superior packing for steam, different from the rest and better. Nugget Packing Co., 185 Summer St., Boston, Mass.

WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

ENGINEERS' SUPPLIES—Wanted, two first-class salesmen in this line for New York city and nearby trade; only those with established trade need apply; no commission work; good position open to right party. Box 458, POWER.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

AT the sale of the famous Robert Hoe collection of books in New York, April 24, the highest price ever paid for a book was brought.

Henry E. Huntington paid $50,000 for the Gutenberg Bible!

The value of this book is not alone in its beauty, nor in its rarity—for there are thirty-four copies in existence. It *is* unique and valuable because it is the first book known to have been printed from movable types.

It was the origin of the modern style of typography.

Way back in 1450 Gutenberg found the way to make printing practical, and from his idea came the evolution of the printing and publishing arts which make it possible for you, today, to surround yourselves with all the books, papers, magazines, etc., that you desire or need.

What Gutenberg did was to see the need of doing something in a newer, better way. He wasn't content with the old methods, so he applied his brain and ingenuity to the task and evolved and adopted a *new* method.

He was one of the men in history who pushed Progress along—not one of the many who wait for Progress to force them into action.

And in his achievement lies a lesson to all of us.

In every power plant there are conditions that can be improved—not necessarily things that have never been done before—but things that *we* have never done before.

If Gutenberg were a modern engineer he would see these things and he wouldn't rest until he had improved them.

He would be a reader of the advertisements because in them the newer and better things are described and illustrated—and he would never be found behind the times for lack of understanding the value of the modern institution, advertising.

The man who paid $50,000 for the Gutenberg Bible bought it because it is a curiosity—he will probably never read it. He will get his value from it in other ways.

Thanks to the old German printer of the 15th century you can buy your technical paper today for two dollars a year—

But, you can't get your value out of it unless you read it—read it carefully, systematically and thoroughly.

Gutenberg gave printing the start that enables modern manufacturers to talk to you by means of the printed word.

The story of all the newer and better things for the power plant comes to you in type each week.

But even Gutenberg couldn't make type speak—*you* must *read* it!

A device that tells you how well the fire is being tended

Tells you how well the fireman is looking after his job.

Shows you exactly what pressure is being carried on the boiler and whether the pressure fluctuated when it should have been steady.

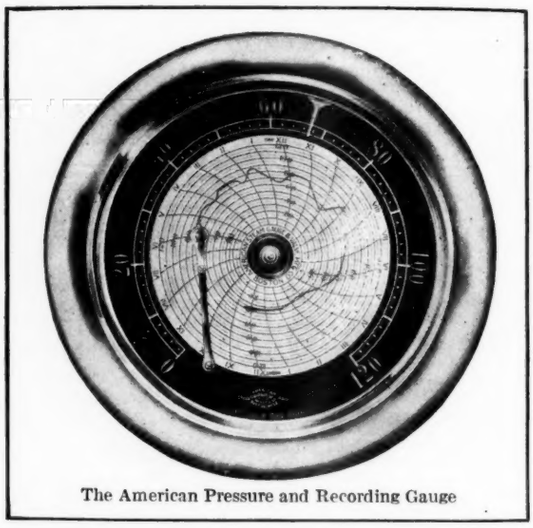
It gives a reliable record of the pressure carried at all times and furnishes daily charts of the fireman's work.

To the power plant manager it offers a chance to watch things going on in the boiler room without leaving his office. It can be installed in the manager's office or in any other part of the plant.

To the engineer and fireman, if their work is well done, it means continual visible proof of personal ability in front of the manager.

It's a device that means coal saving and a stimulus toward good work.

The American Pressure and Recording Gauge



The American Pressure and Recording Gauge

A request brings full details of this and our other steam specialties.

American Steam Gauge & Valve Mfg. Co.

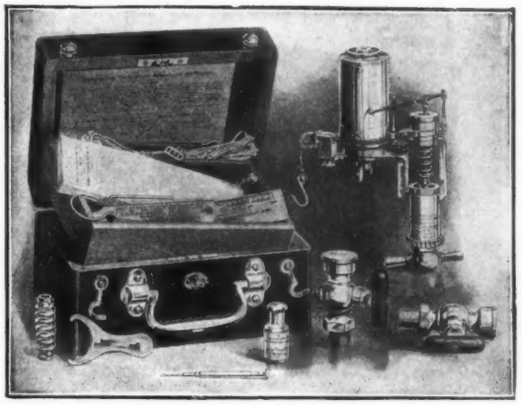
Boston, Mass.

New York, 26 Cortlandt St.
Pittsburg, Columbia Bank Bldg.
Atlanta, 525 Candler Bldg.
San Francisco, Monadnock Bldg.
Chicago, 130-132 Jefferson St.
Montreal, 444 St. James St.

An Interesting Paragraph From the Advertising Editor's Page In Power That Refers To The American-Thompson Indicator

Price

$55.00



$5.00 *Down*

$5.00 *Monthly*

The Following Paragraph Appeared In The Issue Of Feb. 21—Page 328

...olutely
will ... in every particular."

In the same mail we get a letter from a subscriber, who, in renewing his subscription, says: "You may be interested to know that after reading the advertisements of the ~~———~~ Indicator, I bought one and found it to be all they claim for it."

This is the beginning and the ending of ... st... advertising...

The Indicator referred to is the American-Thompson Indicator.

This letter was not a solicited testimonial—it was a frank statement from a subscriber to Power made to the publishers.

It furnishes the clearest kind of proof that Power readers can safely order their American-Thompson Indicators knowing that they will receive the finest Indicator made.

Send your first payment ($5.00) with reference today and let us get your American-Thompson started your way. Act on this proposition now.

Important Facts For Ambitious Engineers

The American-Thompson is made on quality lines all the way through.

In no part is quality sacrificed in order to make the selling price low.

It is sold for $55—and is worth every cent of its price. If the price were doubled it would still be less expensive in the long run than indicators with a lower price but without the American-Thompson staying quality and lasting accuracy.

The owner of an American-Thompson knows that no other engineer has as good an instrument as his, excepting another owner of an American-Thompson.

It is backed by over forty years of experience in the making of Precision Instruments—thousands are in use—progressive engineers everywhere use them because of their unfailing dependability.

If you are ambitious to advance in your profession an American-Thompson Indicator will be the biggest help you could get.

The coupon will bring you further particulars. Sign and mail it.

Send The Attached Mailing Tag Properly Signed For Booklet And Proposition No. 109

American Steam Gauge and Valve Mfg. Co., Boston, Mass.

Send me full details of your Indicator Offer No. 109

Name.....

Address.....

City and State.....

POSITION—Advertising manager wanted by large New England concern; must have mechanical engineering education and had experience in writing advertising copy, sales and promotion letters and literature. Box 436, POWER.

WANTED—A second engineer capable of handling steam and gas power in electric light and power plant of 400 horsepower capacity; state age, qualifications, salary expected and send references; applications to be in by May 15, 1911. E. Roberts, Secretary-Treasurer, Wetaskiwin, Alberta.

WANTED—A first class representative in Pittsburg to handle a reliable high speed engine account on commission basis; prefer a representative who is at present, and will continue, handling power plant equipment that does not compete with the high speed type engine. Box 421, POWER.

DRAFTSMAN, experienced on electric power station work, able to design structural work, piping layouts, draft systems and other work pertaining to the mechanical end; state experience, age and salary wanted; no attention will be paid applications not complying with each of above requirements. Address "C. R.," 794 Broad St., Newark, N. J.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

WANTED—Position by engineer to take charge of steam, electric, or refrigerating plant; have had wide experience and can furnish good references. Address "J. C.," POWER.

SUPERINTENDENT, gas engine, electric light plant, experienced in complete installations, five years installing, three years operating, open for engagement. Address Box 82, Danbury, Ia.

POSITION WANTED by first class Corliss engine draftsman with experience on pumping engines, special machinery and boilers; technically trained and with shop experience. Box 437, POWER.

POSITION WANTED—Superintendent of electric light and power plant or municipal light and water works; fifteen years' experience; first class references; will go anywhere. Address Box X75, POWER, 1214 People's Gas Bldg., Chicago.

WANTED—Young man of 25 wants position as operating engineer; eight years' experience with steam-electric machinery; licensed; capable of taking charge; references. Address E. E. Webb, 500 East Seventh St., Beardstown, Ill.

TECHNICAL MAN, 34, married, 13 years' experience, power, light, telephone, construction and operation, want connection as electrical engineer or superintendent, light or power plant; good business ability; prefer West or South; would consider foreign country. Box 433, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS. C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

The Vulcan Soot Cleaner offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

SUBSCRIBE NOW for the 1911 issue of the Stationary Engineers' Directory of the city of Philadelphia; $5 per copy. Mail checks to Stationary Engineers' Club, 1108 Arch street, Philadelphia, Penn.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

AIR COMPRESSOR, 6x6, belt driven, horizontal, brand new, perfect condition, $135. Box 432, POWER.

ONE IDE HIGH SPEED automatic engine, 10x14 inches; shaft governor, heavy flywheel, out board bearing. Box 435, POWER.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—50 horsepower horizontal tube Bigelow boiler, 35 horsepower Greenfield vertical engine, both in good condition; will sell together or separately. General Acoustic Company, Jamaica, N. Y.

FOR SALE—One compound Reynolds Corliss engine, high pressure cylinder 32 inches, low pressure 60 inches, stroke 60, 1200 horsepower at 100 pounds pressure, 70 revolutions per minute, flywheel diameter 20 feet, face 56 inches, built in sections; shaft length 16 feet diameter in wheel 16 inches, single eccentric. Box 434, POWER.

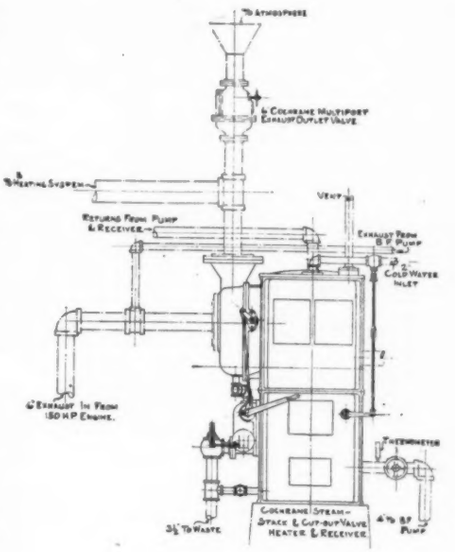
ALPHABETICAL INDEX *to* ADVERTISERS

	PAGE
Air-Flex Co.	104
Ajax Iron Works.	112
Albany Lubricating Co.	81
Alberger Condenser Co.	97
Allis-Chalmers Co.	75
Alton, Laine & Co.	106
American District Steam Co.	110
American Eng. Co.	116
American Goetze-Gasket and Packing Co.	94
American Mfg. Co.	4th cover
American Metal Hose Co.	78
American School of Correspondence	111
American Ship Windlass Co.	76
American Steam Gauge and Valve Mfg. Co.	60 and 61
American Well Works.	95
Ames Iron Works.	114
Anderson Co., V. D.	89
Armstrong Mfg. Co.	84
Ashcroft Mfg. Co., The.	85
Ashton Valve Co.	86
Austin Separator Co.	90
Babcock & Wilcox Co.	101
Baker Valve Co.	113
Ball & Wood Co.	116
Ball Engine Co.	117
Baragwanath & Son, Wm.	99
Barnes Co., W. F. & John	84
Bayer Steam Soot Blower Co.	74
Beggs & Co., James.	130
Betson Plastic Fire Brick Co.	104
Bignall & Keeler Mfg. Co.	83
Blake & Knowles Steam Pump Works	98
Bogart Gas Power Engineering Co.	112
Bristol Co.	4th cover
Bruce-Macbeth Engine Co.	88
Buckeye Engine Co.	114
Builders Iron Foundry.	78
Burt Mfg. Co.	18
Cade & Knapp.	75
Cameron Steam Pump Works, A. S.	96
Cancos Mfg. Co.	94
Casey-Hedges Co.	102
Cataract Refining & Mfg. Co.	80
Chapman Valve Mfg. Co.	86
Chesterton Co., A. W.	110
Columbian Rope Co.	88
Consolidated Safety Valve Co.	85
Cooper Co., C. & G.	113
Crosby Steam Gage & Valve Co.	79
Curtis & Curtis Co.	83
Dart Mfg. Co., E. M.	83
De Laval Steam Turbine Co.	110
Dearborn Drug & Chemical Works	5
Deming Co.	97
Detroit Lubricator Co.	79
Diamond Rubber Co.	93
Dixon Crucible Co., Jos.	79
Du Bois Iron Works.	113
Elliott Co.	7, 81, 86, 88 and 98
Epping-Carpenter Co.	97
Eureka Packing Co.	70
Fitchburg Steam Engine Co.	114
Flexible Steel Lacing Co.	96
Foos Gas Engine Co.	112
Fort Wayne Electric Works.	106
Garlock Packing Co.	9
General Electric Co.	107
Goulds Mfg. Co.	97
Greene, Tweed & Co.,	80 and 4th cover
Griffith & Wedge Co.	114
Griscom-Spencer Co.	99
Hammel Oil Burner Co.	88
Hancock Inspirator Co.	85
Harbison-Walker Refractories Co.	105
Harris Steam Engine Co., W. A.	114
Harrisburg Fdry. and Mach. Works	116
Harrison Safety Boiler Wks.	63
Hawkes Boiler Co.	103
Hayden & Derby Mfg. Co.	85
Heine Safety Boiler Co.	104
Hewes & Phillips Iron Wks.	115
Hoffman, Geo. W.	106
Homestead Valve Mfg. Co.	86
Hooven, Owens, Rentschler Co.	115
Hoppes Mfg. Co.	98
Hughson Steam Specialty Co.	83
Huyette Co., Inc., Paul B.	94
Ingersoll-Rand Co.	88
International Corr. Schools.	67
Jamieson & Co., M. W.	96
Jefferson Union Co.	10
Jeffrey Mfg. Co., The.	75
Jenkins Bros.	65
Johns-Manville Co., H. W.	74
Keeler Co., E.	102
Kellogg Co., The M. W.	83
Kennicott Co.	78
Kerr Turbine Co.	111
Keystone Lubricating Co.	3
Kingsford Fdry. & Mach. Wks.	102
Kinkead Mfg. Co.	94
Lagonda Mfg. Co.	3d cover
Laidlaw-Dunn-Gordon Co.	114
Liberty Mfg. Co.	7
Long Grate Bar Co.	76
Lunkenheimer Co.	4
McClave-Brooks Co.	14
McCord Mfg. Co.	73
McGraw-Hill Book Co.	108
McIntosh, Seymour & Co.	115
McLeod & Henry Co.	104
Magnolia Metal Co.	110
Manning, Maxwell & Moore.	85
Manzel Bros. Co.	80
Mason Regulator Co.	84
Minneapolis Steel & Mach. Co.	113
Monarch Valve & Mfg. Co.	84
Morehead Mfg. Co.	90
Morrin Climax Boiler Co.	102
Murphy Iron Works.	78
Nashua Machine Co.	72
National Pipe Bending Co.	99
National Tube Co.	69
Neemes Bros.	76
Nelson Valve Co.	87
New Bedford Valve Mfg. Co.	86
New Process Raw Hide Co.	88
New York & New Jersey Lubricant Co.	79
New York Belting & Packing Co., Ltd.	12
New York Edison Co.	75
Newhall Engr. Co., Geo. M.	91
Northern Equipment Co.	69
Nuggett Packing Co.	94
Ohio Blower Co.	109
Ohio Brass Co.	84
Oil City Boiler Works.	102
Oil Well Supply Co.	101
Open Coil Heater & Purifier Co.	89
Parson Mfg. Co.	78
Patterson & Co., Frank L.	98
Peerless Rubber Mfg. Co.	8
Penberthy Injector Co.	13
Pennsylvania Flexible Metallic Tubing Co.	104
Perfection Grate Co.	76
Pierce Co., Wm. B.	2d cover
Pittsburgh Valve, Fdry. and Construction Co.	86
Powell Co., Wm.	84
Power Specialty Co.	94
Precision Instrument Co.	88
Providence Engineering Wks.	114
Quaker City Rubber Co.	92
Reliance Gauge Column Co.	89
Rhoads & Sons, J. E.	1st cover
Richardson-Phenix Co.	81
Ridgway Dynamo and Engine Co.	116
Robb Engineering Co., Ltd.	102
Robertson & Sons, Jas. L.	71
Rollins Engine Co.	116
Rooksby & Co., E. J.	115
St. John, G. C.	69
Salamander Grate Bar Co.	76
Scaife & Sons Co., Wm. B.	96
Schieren Co., Chas. A.	88
Schuchardt & Schutte.	106
Schutte & Koerting Co.	97
Simonds & Co., G. L.	101
Simplex Engineering Co.	83
Skinner Engine Co.	116
Smooth-On Mfg. Co.	6
Squires Co., C. E.	89
Standard Grate Co.	76
Starrett Co., L. S.	112
Steam Appliance Co., The.	79
Struthers-Wells Co.	112
Sturtevant Co., B. F.	115
Thermoid Rubber Co.	11
Toledo Pipe Threading Machine Co.	84
Treadwell Co., M. H.	76
Trill Indicator Co.	69
Trimont Mfg. Co.	82
Turbo-Blower Co.	78
Turner-Fricke Mfg. Co.	112
Uehling Instrument Co.	104
Under-Feed Stoker Company of America	77
Underwood & Co., H. B.	115
Union Steam Pump Co.	97
Universal Lubricator Co.	15
Vacuum Ventilator Co.	69
Vilter Mfg. Co.	116
Vogt Machine Co., Henry.	102
Von Kokeritz & Co., R. G.	94
Vulcan Soot Cleaner Co.	101
Walton Co., F. S.	16 and 17
Washburn & Granger.	76
Watson & McDaniel Co.	96
Watts-Campbell Co.	116
Westinghouse Elec. & Mfg. Co.	118
Wheeler Mfg. Co., C. H.	96
Whitlock Coil Pipe Co.	98
Wickes Boiler Co.	102
Willcox Engineering Co.	96
Williams & Co., J. H.	106
Williams Fdry. & Mach. Co.	88
Williams Tool Co.	99
Wing Mfg. Co., L. J.	76
Worthington, Henry R.	96
Wright Mfg. Co.	90
Wyckoff & Son Co., A.	83
Yale & Towne Mfg. Co.	79
Ziermore Regulator Co.	104

Saving A Ton Of Coal A Day In A 150 H. P. Plant

A gentleman who at our request recently visited a wall paper company's power plant, in which we some time ago installed a **COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATER AND RECEIVER** in connection with an exhaust steam heating system, writes us as follows:

> *"Mr. ———— states that he has saved over a ton of coal a day, heats the old building and the new building, measuring 300 ft. by 50 ft., and three stories high, saving him a new boiler, and the heater has paid for itself to date."*



If you can save a ton of coal a day by applying the exhaust steam from a 150 H. P. engine to heating the plant, how much could you save in your plant? Figure it out.

A ton of coal a day, you see, is something like **500** Dollars a year, or more if you are using hard coal. Isn't that worth going after?

The **COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATER AND RECEIVER** not only reheats the condensed returns, and supplements them with raw cold water to make up the boiler feed, but it also purifies of oil all the exhaust steam delivered by the engine, as shown in the accompanying diagram, so that it can safely be passed to the heating and drying coils, and will not foul the latter with grease, and the condensed returns can be brought back and used for boiler feeding, since the steam has been entirely purified of oil by its passage through the extra large separator attached to and forming a part of the heater.

If it is necessary to operate the heating system 24 hours per day, that need not interfere with occasionally cleaning the heater, since valves are incorporated between the separator and the heater, and between the trap which drains the separator and the heater, so that the latter can be cut out of service for cleaning or inspection while the trap and separator remain in service. These valves are connected together by a **FOOL-PROOF** valve gear, so that you cannot turn one valve without turning the other; moreover, while you are opening the heater you can take the handle off, so that no one can turn steam in on you.

If you are interested in the utilization of exhaust steam for heating or drying purposes, you should read our "*Exhaust Steam Heating Encyclopedia*," which describes all the commercial exhaust steam heating systems. We shall be pleased to send you a copy of this book if *you* will kindly give

(1) Your address and the name of the firm with which you are connected, also
(2) The horse-power capacity of the plant and
(3) The present temperature and method of heating your boiler feed water.

HARRISON SAFETY BOILER WORKS

17th and Clearfield Streets Philadelphia, Pa.

After May 1, 1911, our New England Office will be located at 1045 Oliver Bldg., Boston, Mass.

CLASSIFIED INDEX *to* ARTICLES ADVERTISED

Air Compressors
Allis-Chalmers Co. 75
American Wells Co. 95
Ingersoll-Rand Co. 88
Laidlaw-Dunn-Gordon Co. 114
Union Steam Pump Co. 97

Alarms, Low Water
Detroit Lubricator Co. 79
Elliott Co. 7, 81, 86, 88 and 98
Lunkenheimer Co. 4
Reliance Gauge Column Co. 89
Wright Mfg. Co. 90

Alternators
Allis-Chalmers Co. 75
General Electric Co. 107
Westinghouse Elec. & Mfg. Co. 118

Belt Dressing
Garlock Packing Co. 9
Keystone Lubricating Co. 3
Rhoads & Sons, J. E. 1st cover
Schieren Co., Chas. A. 88
Smooth-On Mfg. Co. 6
Walton Co., F. S. 16 and 17

Belt Lacing
Bristol Co. 4th cover
Flexible Steel Lacing Co. 96
Schieren Co., Chas. A. 88

Belting
Diamond Rubber Co. 93
Garlock Packing Co. 9
Jeffrey Mfg. Co. 75
New York Belting & Pack. Co. 10
Peerless Rubber Mfg. Co. 8
Quaker City Rubber Works. 92
Rhoads & Sons, J. E. 1st cover
Schieren Co., Chas. A. 88

Blocks, Chain
Yale & Towne Mfg. Co. 79

Blowers, Fan
Ohio Blower Co. 109
Sturtevant Co., B. F. 115
Turbo-Blower Co. 78
Wing Mfg. Co., L. J. 76

Blowers, Steam Jet
McClave-Brooks Co. 14
Parson Mfg. Co. 78
Schutte & Koerting Co. 97

Boiler Compound
Dearborn Drug and Chemical Works 5
Elliott Co. 7, 81, 86, 88 and 98
Johns-Manville Co., H. W. 74
Keystone Lubricating Co. 3

Boiler Fronts
Casey-Hedges Co. 102

Boiler Setting
Air-Flex Co. 104
Betson Plastic Fire Brick Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co. 104

Boiler Tube Cap Reseating Machine
Elliott Co. 7, 81, 86, 88 and 98
Lagonda Mfg. Co. 3d cover
Liberty Mfg. Co. 7
National Tube Co. 69

Boiler Tubes
Kennicott Co. 78
National Tube Co. 69

Boilers
American Wells Co. 95
Ames Iron Works. 114
Babcock & Wilcox Co. 101
Beggs & Co., James. 100
Casey-Hedges Co. 102
Griffith & Wedge Co. 114
Griscom-Spencer Co. 99
Harrisburg Foundry & Mach. Works 116
Harrison Safety Boiler Wks. 63
Hawkes Boiler Co. 103
Heine Safety Boiler Co. 104
Hewes & Phillips Iron Wks. 115
Keeler Co., E. 102
Kennicott Co. 78
Kingsford Fdry. & Mach. Co. 102
Minneapolis Steel & Mchy. Co. 113
Morrin Climax Boiler Co. 102
New Bedford Valve Mfg. Co. 86
Oil City Boiler Works. 102
Oil Well Supply Co. 101
Robb Engineering Co., Ltd. 102
Struthers-Wells Co. 112
Vilter Mfg. Co. 116

Boilers—*Continued.*
Vogt Machine Co., Henry. 102
Wickes Boiler Co. 102

Books
American School of Corr. 111
International Corr. Schools. 67
McGraw-Hill Book Co. 104

Brick, Fire
Air-Flex Co. 108
Betson Plastic Fire Brick Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co. 104

Castings, Brass and Iron
Bruce-Macbeth Eng. Co. 88
Builders Iron Foundry. 78
Hooven, Owens, Rentschler Co. 115
Lunkenheimer Co., The. 4
McClave-Brooks Co. 14
Neemes Bros. 76
Ohio Brass Co. 84
Salamander Grate Bar Co. 76
Treadwell & Co., M. H. 76

Castings, Steel
Hooven, Owens, Rentschler Co. 115

Cement, Heat Resisting
Air-Flex Co. 108

Cement, Iron
Johns-Manville Co., H. W. 74
Smooth-On Mfg. Co. 6

Cement, Rubber
Peerless Rubber Mfg. Co. 8

Chimneys, Brick
Kellogg Co., M. W. 83

Chimneys, Steel
Keeler Co., E. 102
Morrin Climax Boiler Co. 102

Clocks
American Steam Gauge and Valve Mfg. Co. 60 and 61

Clutches, Friction
Allis-Chalmers Co. 75
Williams Fdry. & Mach. Co. 88

Cocks, Blow-off
Elliott Co. 7, 81, 86, 88 and 98
Hancock Inspirator Co. 85

Cocks, Gage
American Steam Gauge and Valve Mfg. Co. 60 and 61
Huyette Co., Paul B. 94
Jenkins Bros. 65
Lunkenheimer Co., The. 4
Ohio Blower Co. 109
Ohio Brass Co. 84
Reliance Gauge Column Co. 89
Wright Mfg. Co. 90

Cocks, Steam
Dart Mfg. Co., E. M. 83
Lunkenheimer Co. 4
National Tube Co. 69
Schutte & Koerting Co. 97

Combustion Chamber, Back Arch
Air-Flex Co. 108
Betson Plastic Fire Brick Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co. 104

Combustion Recorders
Precision Instrument Co. 88
Uehling Instrument Co. 104

Compound, Commutator
Dixon Crucible Co., Jos. 79

Condensers
Alberger Condenser Co. 97
Allis-Chalmers Co. 75
Anderson Co., V. D. 89
Baragwanath & Son, Wm. 99
Cameron Steam Pump Works, A. S. 96
Epping-Carpenter Co. 97
Griscom-Spencer Co. 99
Kellogg Co., M. W. 83
Minneapolis Steel & Mchy. Co. 113
Schutte & Koerting Co. 97
Union Steam Pump Co. 97
Wheeler Mfg. Co., C. H. 96

Controllers, Electric
General Electric Co. 107
Westinghouse Elec. & Mfg. Co. 118

Controllers, Feed Water
Elliott Co. 7, 81, 86, 88 and 98
Mason Regulator Co. 84
Northern Equipment Co. 69
Squires Co., C. E. 89
Ziermore Regulator Co. 104

Conveying Machinery
Jeffrey Mfg. Co. 75

Cooling Plants
Schutte & Koerting Co. 97

Cooling Towers
Wheeler Mfg. Co., C. H. 96

Cordage
American Mfg. Co. 4th cover
Columbian Rope Co. 88

Correspondence Schools
American School of Corres. 111
International Corr. Schools. 67

Couplings, Flexible Shaft
Bruce-Macbeth Engine Co. 88
Hooven, Owens, Rentschler Co. 115

Couplings, Hose
Ingersoll-Rand Co. 88

Couplings, Pipe
Lagonda Mfg. Co. 3d cover
Liberty Mfg. Co. 7

Coverings, Pipe and Boiler
Johns-Manville Co., H. W. 74
Wyckoff & Son Co., A. 83

Cranes
Yale & Towne Mfg. Co. 79

Crank Pin Oiler
Richardson-Phenix Co. 81

Curbs, Manhole
Armstrong Mfg. Co. 84

Cylinder Boring Bars
Underwood & Co., H. B. 115

Die Stocks
Armstrong Mfg. Co. 84
Bignall & Keeler Mfg. Co. 83
Curtis & Curtis Co. 83
Toledo Pipe Threading Mach. Co. 84

Draft, Mechanical
Parson Mfg. Co. 78
Schutte & Koerting Co. 97
Sturtevant Co., B. F. 115
Turbo-Blower Co. 78
Wing Mfg. Co., L. J. 76

Drills, Upright
Barnes Co., W. F. & John. 84

Dust Collectors
Ohio Blower Co. 109
Sturtevant Co., B. F. 115

Dynamos
Allis-Chalmers Co. 75
American Engine Co. 116
Bruce-Macbeth Eng. Co. 88
Fort Wayne Electric Works. 106
General Electric Co. 107
Ridgway Dynamo and Engine Co. 116
Sturtevant Co., B. F. 115
Westinghouse Elec. & Mfg. Co. 118

Economizers, Fuel
Parsons Mfg. Co. 78
Sturtevant Co., B. F. 115

Ejectors
Beggs & Co., James. 100
Hayden & Derby Mfg. Co. 85
Lunkenheimer Co. 4
Penberthy Injector Co. 13
Schutte & Koerting Co. 97

Electric Current
New York Edison Co. 75

Engine Repairs
Rooksby & Co., E. J. 115
Underwood & Co., H. B. 115

Engine Stops
Schutte & Koerting Co. 97

Engines, Combustion
Ajax Iron Works. 112
Allis-Chalmers Co. 76
American Wells Co. 95
Bogart Gas Power Engineering Co. 112
Bruce-Macbeth Eng. Co. 88
Buckeye Engine Co. 114

Engines, Combustion—*Cont.*
Du Bois Iron Works. 113
Foos Gas Engine Co. 112
Minneapolis Steel & Mchy. Co. 113
Struthers-Wells Co. 112
Turner-Fricke Mfg. Co. 112

Engines, Pumping
Hooven, Owens, Rentschler Co. 115

Engines, Steam
Allis-Chalmers Co. 76
American Eng. Co. 116
American Wells Co. 95
Ames Iron Works. 114
Ball & Wood Co. 116
Ball Engine Co. 117
Beggs & Co., James. 100
Buckeye Engine Co. 114
Cooper Co., C. & G. 113
Du Bois Iron Works. 113
Fitchburg Steam Engine Co. 114
Griffith & Wedge Co. 114
Griscom-Spencer Co. 99
Harris Steam Eng. Co., Wm. A. 114
Harrisburg Fdry & Mach. Wks. 116
Hewes & Phillips Iron Wks. 115
Hooven, Owens, Rentschler Co. 115
McIntosh, Seymour & Co. 115
Minneapolis Steel & Mchy. Co. 113
Providence Engineering Wks. 114
Ridgway Dynamo & Engine Co. 116
Rollins Engine Co. 116
Skinner Engine Co. 116
Sturtevant Co., B. F. 115
Vilter Mfg. Co. 116
Watts-Campbell Co. 116

Exhaust Heads
Burt Mfg. Co. 18
Elliott Co. 7, 81, 86, 88 and 98
Hoppes Mfg. Co. 98
Ohio Blower Co. 109
Patterson & Co., Frank L. 98
Robertson & Sons, Jas. L. 71
Sturtevant Co., B. F. 115
Whitlock Coil Pipe Co. 98
Wright Mfg. Co. 90

Expansion Joints
Alberger Condenser Co. 97
National Tube Co. 69

Fans, Electric
General Electric Co. 107
Fort Wayne Electric Works. 78
Westinghouse Elec. & Mfg. Co. 118

Fans, Exhaust and Ventilating
Anderson Co., V. D. 89
General Electric Co. 78
Power Specialty Co. 94
Schutte & Koerting Co. 97
Sturtevant Co., B. F. 115
Turbo-Blower Co. 75
Westinghouse Elec. & Mfg. Co. 118
Wing Mfg. Co., L. J. 76

Feed Water Weighers
Kennicott Co., The. 78
Willcox Engineering Co. 96

Feeders, Boiler Compound
Richardson-Phenix Co. 81

Feeders, Furnace
Kennicott Co., The. 78
Ohio Blower Co. 109

Filters, Oil
Burt Mfg. Co. 18
Elliott Co. 7, 81, 86, 88 and 98
Liberty Mfg. Co. 7
Richardson-Phenix Co. 81
Robertson & Sons, Jas. L. 71
Wright Mfg. Co. 90

Filters, Water
Griscom-Spencer Co. 99
Scaife & Sons Co., Wm. B. 96

Fire Clay
Air-Flex Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co. 104

Firebox Blocks
Air-Flex Co. 104
Betson Plastic Fire Brick Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co. 104

Fittings, Ammonia
American Steam Gauge and Valve Mfg. Co. 60 and 61

Fittings, Steel
Nelson Valve Co. 87

TRADE JENKINS MARK

JENKINS '96 PACKING

TRADE JENKINS MARK

Jenkins Bros.

Jenkins Bros.

Is Easy To Apply—Keeps The Joints Tight—Is Inexpensive

Three features that make it the packing it will pay you to use.

It can be used in any flange joint, rough or even surfaces, hot or cold, and pressure can be turned on as soon as the joint is made.

It keeps the joints tight, putting an end to continual leak troubles and to the need for constant following-up.

It is a light packing, and yard for yard costs less than any other sheet packings.

Try it—in some joints that have been giving you a lot of annoyance.

Write for our catalog, which illustrates and describes Jenkins Bros. Valves, Jenkins '96 Packing and other specialties

Jenkins Bros.

80 White St., New York

35 High St., Boston

300 West Lake St., Chicago

133 N. 7th St., Philadelphia

Flanges
Ball & Wood Co.....116
Dart Mfg. Co., E. M..... 83
Jefferson Union Co..... 10
National Tube Co..... 69

Floats
Anderson Co., V. D..... 89
Schutte & Koerting Co..... 97

Flue Gas Analysis Instruments
Pierce Co., Wm. B.....2d cover

Forgings, Drop
Williams & Co., J. H.....106

Furnace Door Arch
Air-Flex Co. 104
Harbison-Walker Refractories Co. 105
McLeod & Henry Co.....104

Furnace Linings
Harbison-Walker Refractories Co. 105

Furnaces, Smokeless
McClave-Brooks Co..... 14
Murphy Iron Works..... 78

Gage Boards
American Steam Gauge and Valve Mfg. Co.....60 and 61

Gage Glasses
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashcroft Mfg. Co..... 85
Cade & Knapp..... 75
Chesterton Co., A. W.....110
Garlock Packing Co..... 9
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 92
Von Kokeritz & Co., R. G.... 94

Gage Testing Outfit
American Steam Gauge and Valve Mfg. Co.....60 and 61

Gages, Draft
American Steam Gauge and Valve Mfg. Co.....60 and 61
Bristol Co.....4th cover

Gages, Pressure
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashton Valve Co..... 86
Crosby Steam Gage & Valve Co. 79

Gages, Recording
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashton Valve Co..... 86
Bristol Co.....4th cover
Uehling Instrument Co..... 10

Gages, Vacuum
American Steam Gauge and Valve Mfg. Co.....60 and 61
Schutte & Koerting Co..... 97

Gages, Water
American Steam Gauge and Valve Mfg. Co.....60 and 61
Greene, Tweed & Co., 80 and 4th cover
Huyette Co., Paul B..... 94
Jenkins Bros..... 65
Lunkenheimer Co..... 4
Ohio Blower Co.....109
Reliance Gauge Column Co... 89
Wright Mfg. Co..... 90

Gas Exhausters
Ohio Blower Co.....109

Gas Producers
Bogart Gas Power Engineering Co. 112
Du Bois Iron Works.....113
Foos Gas Engine Co.....112
Griscom-Spencer Co..... 99
Minneapolis Steel & Mchy. Co.113

Gaskets
American Goetze-Gasket and Packing Co..... 94
Cancos Mfg. Co..... 94
Diamond Rubber Co..... 93
Eureka Packing Co..... 70
Garlock Packing Co..... 9
Greene, Tweed & Co., 80 and 4th cover
Jenkins Bros..... 65
Johns-Manville Co., H. W.... 74
Keeler Co., E.....102
McCord Mfg. Co..... 73
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 92

Gears
New Process Raw Hide Co... 88

Generating Sets
American Engine Co.....116
Foos Gas Engine Co.....112
Fort Wayne Electric Works..106
General Electric Co.....107
Harris Steam Engine Co., Wm.114
Harrisburg Foundry and Machine Works.....116
Ridgway Dynamo & Engine Co.116
Sturtevant Co., B. F.....115
Westinghouse Elec. & Mfg. Co.118

Governors, Pump
Elliott Co...7, 81, 86, 88 and 98
Mason Regulator Co..... 84
Northern Equipment Co..... 69
Squires Co., C. E..... 89
Watson & McDaniel Co..... 96
Ziermore Regulator Co.....104

Governors, Pump Speed
Mason Regulator Co..... 84
Ziermore Regulator Co.....104

Graphite
Dixon Crucible Co., Jos..... 79
Garlock Packing Co..... 9

Grates
Casey-Hedges Co..... 94
Long Grate Bar Co..... 76
McClave-Brooks Co..... 12
Neemes Bros..... 76
Perfection Grate Co..... 76
Salamander Grate Bar Co.... 76
Standard Grate Co..... 76
Treadwell & Co., M. H..... 76
Washburn & Granger Co..... 76

Grease
Albany Lubricating Co..... 81
Cataract Refining & Mfg. Co.. 80
Dearborn Drug & Chemical Works 5
Dixon Crucible Co., Jos..... 79
Kellogg & Co., E. H..... 83
Keystone Lubricating Co..... 3
Walton Co., F. S.....16 and 17

Grease Extractors
Beggs & Co., James.....100
Elliott Co...7, 81, 86, 88 and 98
Griscom-Spencer Co..... 99

Heaters and Purifiers, Feed Water
Alberger Condenser Co..... 97
Baragwanath & Son, Wm..... 99
Blake & Knowles Steam Pump Works 98
Casey-Hedges Co.....102
Elliott Co...7, 81, 86, 88 and 98
Griscom-Spencer Co..... 99
Harrison Safety Boiler Wks.. 63
Hoppes Mfg. Co..... 98
Kennicott Co..... 78
Minneapolis Steel & Mchy. Co.113
National Pipe Bending Co.... 99
Open Coil Heater & Purifier Co. 89
Patterson & Co., Frank L.... 98
Robertson & Sons, Jas. L.... 71
Wheeler Mfg. Co., C. H..... 96
Whitlock Coil Pipe Co..... 98
Wickes Boiler Co.....102
Willcox Engr. Co..... 96
Williams Tool Co..... 88

Heating and Ventilating Systems
Ohio Blower Co.....109
Schutte & Koerting Co..... 97
Wing Mfg. Co., L. J..... 76

Heating, Central Station
American District Steam Co..110

Hoists, Combustion Engine
Foos Gas Engine Co.....112

Hoists, Electric
Allis-Chalmers Co..... 75
Yale & Towne Mfg. Co..... 79

Hoists, Hand
Yale & Towne Mfg. Co..... 79

Hose, Metal
American Metal Hose Co..... 78
Liberty Mfg. Co..... 7
Pennsylvania Flexible Metallic Tubing Co.....104
Quaker City Rubber Works... 92

Hose, Rubber
Diamond Rubber Co..... 93
Garlock Packing Co..... 9
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8
Pennsylvania Flexible Metallic Tubing Co.....104
Quaker City Rubber Works... 92

Ice and Refrigerating Machinery
Vogt Machine Co., Henry....102
Watts-Campbell Co. 115

Ice Machine Repairs
Underwood & Co., H. B.....116

Indicators, Ammonia
American Steam Gauge and Valve Mfg. Co.....60 and 61

Indicators, Combustion Engine
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashcroft Mfg. Co..... 85
Trill Indicator Co..... 69

Indicators, Speed
Starrett Co., L. S.....112

Indicators, Steam Engine
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashcroft Mfg. Co..... 85
Crosby Steam Gage & Valve Co. 79
Robertson & Sons, Jas. L.... 71
Trill Indicator Co..... 69

Injectors
Hayden & Derby Mfg. Co.... 85
Jenkins Bros..... 65
Lunkenheimer Co..... 4
Penberthy Injector Co..... 13
Robertson & Sons, Jas. L.... 71
Schutte & Koerting Co..... 97

Lamps, Electric
General Electric Co.....107
Johns-Manville Co., H. W.... 74
Westinghouse Elec. & Mfg. Co.118

Lathes, Foot Power
Barnes Co., W. F. & John.... 84

Lubricators, Cylinder
Detroit Lubricator Co..... 79
Greene, Tweed & Co., 80 and 4th cover
Griscom-Spencer Co..... 99
Lunkenheimer Co..... 4
Manzel Bros. Co..... 80
Robertson & Sons, Jas. L.... 71
Richardson-Phenix Co..... 81
Universal Lubricator Co..... 15

Lubricators, Force Feed
Greene, Tweed & Co., 80 and 4th cover
Lunkenheimer Co..... 4
McCord Mfg. Co.....108
Richardson-Phenix Co..... 81

Machinists, General
Bruce-Macbeth Eng. Co..... 88
Providence Eng. Wks.....114

Mats and Matting
Diamond Rubber Co..... 93
New York Belting & Packing Co 10
Peerless Rubber Mfg. Co.... 8

Metal, Bearing
Magnolia Metal Co.....110

Meters, Steam
General Electric Co.....107
St. John, G. C..... 69

Meters, Water
Builders Iron Foundry..... 78
Elliott Co...7, 81, 86, 88 and 98

Micrometers
Starrett Co., L. S.....112

Milling Machines, Portable
Underwood & Co., H. B.....115

Motors, Electric
Allis-Chalmers Co..... 75
American Engine Co.....116
Fort Wayne Electric Works..106
General Electric Co.....107
Ridgway Dynamo & Engine Co 116
Sturtevant Co., B. F.....115
Westinghouse Elec. & Mfg. Co.118

Motors, Water
Elliott Co...7, 81, 86, 88 and 98
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Oil and Grease Cups
Albany Lubricating Co..... 81
Detroit Lubricating Co..... 79
Keystone Lubricating Co.... 3
Liberty Mfg. Co..... 7
Lunkenheimer Co..... 4
New York & New Jersey Lubricant Co..... 79
Richardson-Phenix Co..... 81
Universal Lubricator Co..... 15

Oil Burners
Hammel Oil Burner Co..... 88
Lunkenheimer Co..... 4
Parson Mfg. Co..... 78

Oil Reservoirs
Burt Mfg. Co..... 18
Richardson-Phenix Co..... 81

Oil Tanks
Richardson-Phenix Co..... 81

Oiling Systems
Albany Lubricating Co..... 81
Burt Mfg. Co..... 18
Detroit Lubricator Co..... 79
Elliott Co...7, 81, 86, 88 and 98
Lunkenheimer Co..... 4
Richardson-Phenix Co..... 81

Oils
Albany Lubricating Co..... 81
Dearborn Drug & Chemical Works 5
Kellogg & Co., E. H..... 83
New York & New Jersey Lubricant Co..... 79
Walton Co., F. S.....16 and 17

Packing, Flange
American Goetze-Gasket and Packing Co..... 94
Cancos Mfg. Co..... 94
Chesterton Co., A. W.....110
Diamond Rubber Co..... 93
Eureka Packing Co..... 70
Garlock Packing Co..... 9
Greene, Tweed & Co., 80 and 4th cover
Jenkins Bros..... 65
Johns-Manville Co., H. W.... 74
McCord Mfg. Co..... 73
New York Belting & Packing Co. 10
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 92
Smooth-On Mfg. Co..... 6
Thermoid Rubber Co..... 11
Von Kokeritz & Co., R. G.... 94

Packing, Hydraulic
Johns-Manville Co., H. W.... 74
Quaker City Rubber Works... 92
Von Kokeritz & Co., R. G.... 94

Packing, Pump Valve
Cancos Mfg. Co..... 94
Diamond Rubber Co..... 93
Quaker City Rubber Works... 92
Von Kokeritz & Co., R. G.... 94

Packing, Rod
American Goetze-Gasket and Packing Co..... 94
Cancos Mfg. Co..... 94
Chesterton Co., A. W.....110
Diamond Rubber Co..... 93
Eureka Packing Co..... 70
Garlock Packing Co..... 9
Greene, Tweed & Co., 80 and 4th cover
Johns-Manville Co., H. W.... 74
New York Belting and Packing Co..... 10
Nugget Packing Co..... 94
Peerless Rubber Mfg. Co..... 8
Power Specialty Co..... 94
Quaker City Rubber Works... 92
Thermoid Rubber Co..... 11
Von Kokeritz & Co., R. G..... 92

Pipe
Ball & Wood Co.....116
Kellogg & Co., M. W..... 83
National Tube Co..... 69

Pipe Bending
Ball & Wood Co.....116
Kellogg Co., M. W..... 83
National Pipe Bending Co.... 99
Whitlock Coil Pipe Co..... 98

Pipe Clamp
Simplex Engineering Co..... 83

Pipe Coils
National Pipe Bending Co.... 99
National Tube Co..... 69
Whitlock Coil Pipe Co..... 98

Pipe Cutting and Threading Machines
Armstrong Mfg. Co..... 84
Bignall & Keeler Mfg. Co.... 83
Curtis & Curtis Co..... 85
Toledo Pipe Threading Machine Co..... 84
Trimont Mfg. Co..... 82

Pipe, Riveted Steel
Kennicott Co. 78

Piping, Blower
Kennicott Co., The..... 78
Ohio Blower Co.....109

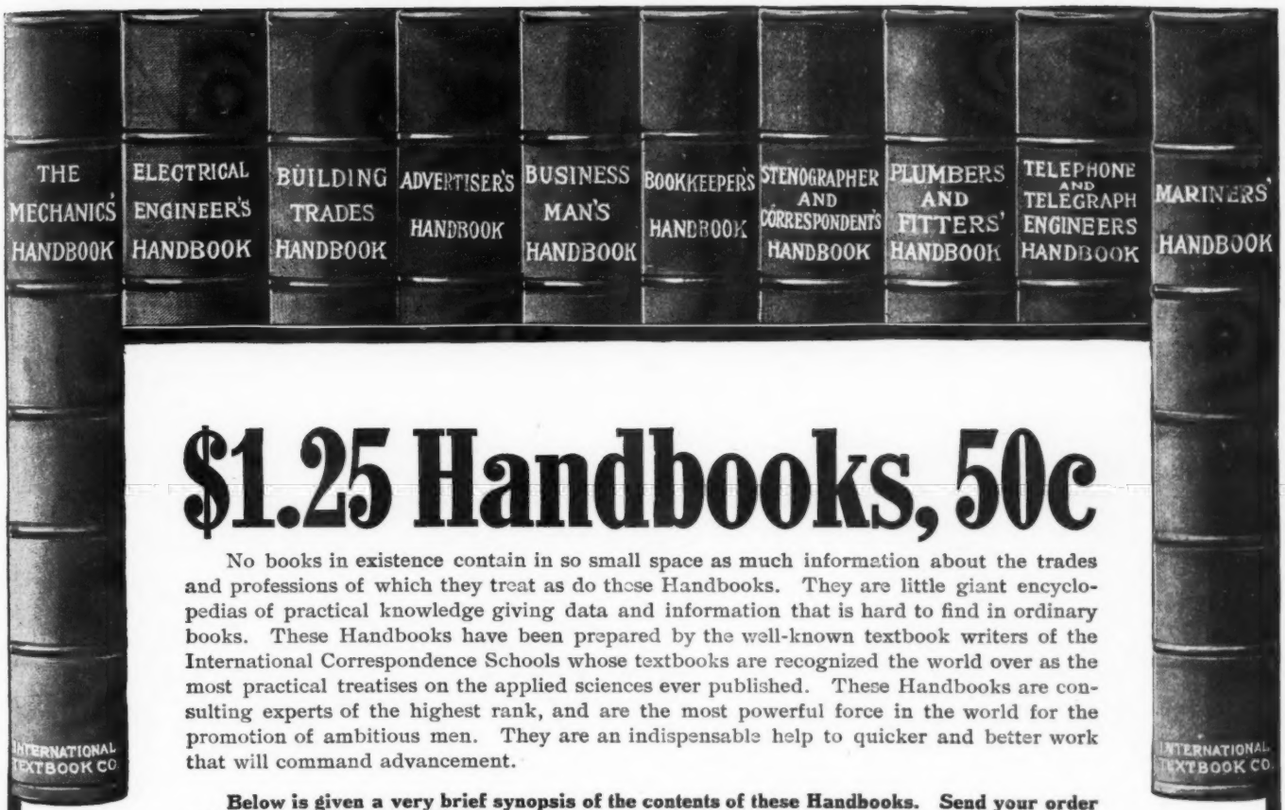
Piping, High Pressure
Kellogg Co., M. W..... 83

Planimeters
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashcroft Mfg. Co..... 85
Robertson & Sons, Jas. L.... 71

Polish, Metal
Hoffman, Geo. W.....106
Johns-Manville Co., H. W.... 74

Publishers
American School of Corr.....111
International Corr. Schools... 67
McGraw-Hill Book Co.....108

Pulleys
Minneapolis Steel & Mchy. Co.113



$1.25 Handbooks, 50c

No books in existence contain in so small space as much information about the trades and professions of which they treat as do these Handbooks. They are little giant encyclopedias of practical knowledge giving data and information that is hard to find in ordinary books. These Handbooks have been prepared by the well-known textbook writers of the International Correspondence Schools whose textbooks are recognized the world over as the most practical treatises on the applied sciences ever published. These Handbooks are consulting experts of the highest rank, and are the most powerful force in the world for the promotion of ambitious men. They are an indispensable help to quicker and better work that will command advancement.

Below is given a very brief synopsis of the contents of these Handbooks. Send your order today on the attached coupon.

Mechanics'.—Tables; formulas; measurements; belting; mechanical powers; hydromechanics; strength of materials; shafting; boiler design; care of boilers; power of boilers; chimneys; exhaust heating; machine design; machine tools; slide valve; pulleys; cylinders and steam chests; pistons; gearing; transit surveying; triangulation; curves; radii and deflections; earth work; track work; electricity; etc.

Electrical Engineer's.—Mechanics; electrical units; physical and electrical properties of metals and alloys; temperature for copper wires; wire gauges; magnetism; dynamos and motors; electric batteries; alternating current apparatus; alternators; transformers; wattmeters; electric transmission; electric lamps; wiring; electric heating and welding; electromagnets; controllers; car wiring; etc.

Building Trades.—Loads and structures; strength of materials; properties of sections; strength of rivets and pins; materials of construction; footings and foundations; masonry construction; woods used in building; qualities of timbers; joinery; framing; estimating; elements of architectural design; drainage systems; plumbing fixtures; plumbers' tables; heating and ventilation; gas-fitting; etc.

Advertiser's.—How to plan and write an advertisement; type and type measurement; points on printing style; advertisement display; preparation of manuscript; proof reading; engraving and printing methods; electrotypes; matrices; advertisement illustrations; magazines; newspapers; retail, department-store, general, trade-paper, and mail-order advertising; trade marks; circulars; advertising agencies, etc.

Business Man's.—Arithmetic; tables; business forms; card systems; measures of extension; weight and capacity; time; value of foreign coins; duties on imports; bookkeeping; stenography; correspondence; postal information; financial terms; money and the money market; brokers and brokerage; patents; copyright and trade marks; corporations; business law; publicity; etc.

Mariners'.—Useful tables; logarithms; trigonometry; navigation; terrestrial navigation; celestial navigation; sailing distances; U. S. Navy; classification of war ships; organization of a man of war; naval ordnance; explosives; torpedoes; ship building; speed, tonnage, and fuel consumption; ropes; wind and weather; signals; nautical memoranda; U. S. naturalization laws; custom-house fees, etc.

Stenographer's & Correspondent's

Advice to beginners; shorthand speed; technical terms; commonly used foreign words and phrases; letters of application; punctuation; correct and faulty diction; business correspondence; typewriting; abbreviations; addressing; mailing; rates of postage; modern office methods; typewriting forms; duplicating work; etc.

Plumbers and Fitters'.—Arithmetic; involution and evolution; powers, roots, and reciprocals; table of circles; decimals; geometrical drawing; weights and measures; mechanical powers; blue prints; formulas; mensuration; mechanics; hydromechanics; building construction; heating and ventilation; gas and gas-fitting; plumbing; etc.

Telephone and Telegraph.—Useful tables; powers, roots, and reciprocals; mechanics; electricity; magnetism; primary batteries; storage batteries; electrical measurements; telephony; tests with magneto-generator and bell; telegraphy; Morse telegraph systems; multiplex telegraphy; simultaneous telegraphy and telephony; etc.

Bookkeeper's.—Arithmetic; formulas; tables; money; percentage; interest; equation of accounts; money and the money market; business law; financial terms; banks and banking; postal information; distances and time between various places; bookkeeping; business forms; card systems; modern office methods; cost accounting; bank bookkeeping; clearing-house methods; etc.

SPECIAL OFFER.—For a limited time we are selling these Handbooks durably bound in cloth, with gilt titles, containing on an average of 375 pages and 175 illustrations, and regularly sold at $1.25, at a price for each Handbook of . . . **50c**

International Textbook Company

Box 979, SCRANTON, PA.

I enclose $_____ for which please send me the books **BEFORE** which I have marked **X**.

__ Mechanics' Handbook	__ Advertiser's Handbook
__ Electrical Engineer's Handbook	__ Bookkeeper's Handbook
__ Building Trades Handbook	__ Steno. & Corr. Handbook
__ Plumbers & Fitters' Handbook	__ Business Man's Handbook
__ Tel. & Tel. Handbook	__ Mariners' Handbook

Name _____

Street and No. _____

City _____ *State* _____

Pumps, Air
American Wells Co..... 95
Cameron Steam Pump Wks., A. S..... 96
Du Bois Iron Works.....113
Goulds Mfg. Co..... 97
Wheeler Mfg. Co., C. H..... 96

Pumps, Centrifugal
Alberger Condenser Co..... 97
Allis-Chalmers Co..... 75
American Wells Co..... 95
De Laval Steam Turbine Co..110
Worthington, Henry R..... 96

Pumps, Deep Well
American Wells Co..... 95
Cameron Steam Pump Wks., A. S..... 96
Deming Co. 97

Pumps, Electric
American Wells Co..... 95
De Laval Steam Turbine Co..110
Deming Co. 97
Du Bois Iron Works.....113
Goulds Mfg. Co..... 97
Westinghouse Elec. & Mfg. Co.118

Pumps, Oil
American Wells Co..... 95
Burt Mfg. Co..... 18
Cameron Steam Pump Wks., A. S..... 96
Du Bois Iron Works.....113
Goulds Mfg. Co..... 97
Lunkenheimer Co..... 4
Manzel Bros. Co..... 80

Pumps, Oil Force-feed
Detroit Lubricator Co..... 79
Lunkenheimer Co..... 4
Richardson-Phenix Co. 81

Pumps, Pneumatic
Ingefsoll-Rand Co. 88

Pumps, Power
American Wells Co..... 95
Deming Co..... 97
Du Bois Iron Works.....113
Goulds Mfg. Co..... 97
Patterson & Co., Frank L.... 98
Union Steam Pump Co..... 97
Whitlock Coil Pipe Co..... 98

Pumps, Steam
Allis-Chalmers Co..... 75
American Wells Co..... 95
Cameron Steam Pump Wks., A. S..... 96
De Laval Steam Turbine Co..110
Du Bois Iron Works.....113
Epping-Carpenter Co..... 97
Goulds Mfg. Co..... 97
Ingersoll-Rand Co..... 88
Jamieson & Co., M. W..... 96
Minneapolis Steel & Mchy. Co.113
Union Steam Pump Co..... 97
Wheeler Mfg. Co., C. H..... 96
Worthington, Henry R..... 96

Pumps, Vacuum
Alberger Condenser Co..... 97
American Wells Co..... 95
Cameron Steam Pump Wks., A. S..... 96
Goulds Mfg. Co..... 97
Union Steam Pump Co..... 97
Wheeler Mfg. Co., C. H..... 96

Pyrometers
American Steam Gauge and Valve Mfg. Co.....60 and 61

Rams, Steam
Penberthy Injector Co..... 13

Reducing Wheels
American Steam Gauge and Valve Mfg. Co.....60 and 61
Robertson & Sons, Jas. L.... 71
Trill Indicator Co..... 69

Regulators, Damper
Elliott Co...7, 81, 86, 88 and 98
Lagonda Mfg. Co.....3d cover
Mason Regulator Co..... 84
Robertson & Sons, Jas. L.... 71
Turbo-Blower Co..... 78

Regulators, Feed Water
Elliott Co...7, 81, 86, 88 and 98
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
Northern Equipment Co..... 69
Squires Co., C. E..... 89
Ziermore Regulator Co.....104

Regulators, Pressure
American District Steam Co..110
Elliott Co...7, 81, 86, 88 and 98
Hughson Steam Specialty Co. 83
Lagonda Mfg. Co.....3d cover
Mason Regulator Co..... 84
Northern Equipment Co..... 69
Squires Co., C. E..... 89
Steam Appliance Co..... 79
Ziermore Regulator Co.....104

Regulators, Pump
Elliott Co...7, 81, 86, 88 and 98
Hughson Steam Specialty Co. 83
Mason Regulator Co..... 84
Squires Co., C. E..... 89
Ziermore Regulator Co.....104

Revolution Counters
American Steam Gauge and Valve Mfg. Co.....60 and 61

Rheostats
General Electric Co.....107

Rope, Transmission
American Mfg. Co.....4th cover
Columbian Rope Co..... 88

Rubber Joints
Diamond Rubber Co..... 93
Quaker City Rubber Works... 92

Second Hand Machinery
Blake & Knowles Steam Pump Works 98

Separators, Ammonia
Elliott Co...7, 81, 86, 88 and 98
Harrison Safety Boiler Wks.. 63

Separators, Oil
Austin Separator Co..... 90
Baragwanath & Son, Wm..... 99
Elliott Co...7, 81, 86, 88 and 98
Harrison Safety Boiler Wks.. 63
Hoppes Mfg. Co..... 98
Liberty Mfg. Co..... 7
Nashua Machine Co..... 72
Ohio Blower Co.....109
Robertson & Sons, Jas. L.... 71
Steam Appliance Co..... 79
Wright Mfg. Co..... 90

Separators, Steam
Austin Separator Co..... 90
Baragwanath & Son, Wm..... 99
Elliott Co...7, 81, 86, 88 and 98
Griscom-Spencer Co..... 99
Harrison Safety Boiler Wks.. 63
Hoppes Mfg. Co..... 98
Liberty Mfg. Co..... 7
Nashua Machine Co..... 72
Ohio Blower Co.....109
Patterson & Co., Frank L.... 98
Robertson & Sons, Jas. L.... 71
Steam Appliance Co..... 79
Whitlock Coil Pipe Co..... 98
Wright Mfg. Co..... 90

Shafting, Alining and Leveling Apparatus
Kinkead Mfg. Co..... 94

Sight Feeds
Richardson-Phenix Co. 81

Skylights
Burt Mfg. Co..... 18

Stokers, Mechanical
American Ship Windlass Co.. 76
Babcock & Wilcox Co.....101
Lagonda Mfg. Co.....3d cover
McClave-Brooks Co..... 12
Murphy Iron Works..... 78
Parson Mfg. Co..... 78
Under-Feed Stoker Company of America..... 77

Strainers, Pump Suction
American Ship Windlass Co.. 76
Elliott Co...7, 81, 86, 88 and 98

Strainers, Water
Liberty Mfg. Co..... 7
Hayden & Derby Mfg. Co.... 85

Superheaters
Babcock & Wilcox Co.....101
Power Specialty Co..... 94
Providence Engineering Wks.114

Switchboards
General Electric Co.....107
Westinghouse Elec. & Mfg. Co.118

Switches, Electric
General Electric Co.....107

Tachometers
Schuchardt & Schutte.....106

Tanks
Griscom-Spencer Co..... 99
Kennicott Co. 78

Taps, Stocks and Dies
Armstrong Mfg. Co..... 84
Bignall & Keeler Mfg. Co.... 83
Curtis & Curtis Co..... 83
Toledo Pipe Threading Machine Co..... 84

Thermometers
Bristol Co.....4th cover

Tools, Portable Repair
Underwood & Co., H. B.....115

Transformers and Converters
General Electric Co.....107
Jeffrey Mfg. Co..... 75
Westinghouse Elec. & Mfg. Co.118

Traps, Steam
American District Steam Co..110
Anderson Co., V. D..... 89
Elliott Co...7, 81, 86, 88 and 98
Griscom-Spencer Co..... 99
Jenkins Bros..... 65
Morehead Mfg. Co..... 90
Nashua Machine Co..... 72
Newhall Eng. Co., Geo. M.... 91
Ohio Blower Co.....109
Open Coil Heater & Purifier Co 89
Reliance Gauge Column Co... 89

Traps, Steam—*Continued.*
Schutte & Koerting Co..... 97
Squires Co., C. E..... 89
Steam Appliance Co..... 79
Watson & McDaniel Co..... 96
Wright Mfg. Co..... 90

Traps, Vacuum
Griscom-Spencer Co..... 99
Nashua Machine Co..... 72
Open Coil Heater & Purifier Co. 89

Tube Cap Reseating Machines
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Tube Cleaners
Bayer Steam Soot Blower System 74
Chesterton Co., A. W.....110
Garlock Packing Co..... 9
Johns-Manville Co., H. W.... 74
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
Pierce Co., Wm. B.....2d cover
Robertson & Sons, Jas. L.... 71
Simonds & Co., G. L.....101
St. John, S. C..... 69
Steam Appliance Co..... 79
Vulcan Soot Cleaner Co.....101

Tube Cutters
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Tubing
Johns-Manville Co., H. W.... 74
National Tube Co..... 69

Turbines, Hydraulic
Allis-Chalmers Co..... 75

Turbines, Steam
Allis-Chalmers Co..... 75
De Laval Steam Turbine Co..110
General Electric Co.....107
Hooven, Owens, Rentschler Co.107
Kerr Turbine Co.....111
Sturtevant Co., B. F.....115

Unions
Dart Mfg. Co., E. M..... 83
Jefferson Union Co..... 10
Lunkenheimer Co..... 4
National Tube Co..... 69

Valve Balls
Diamond Rubber Co..... 93

Valve Disks
American Goetze-Gasket and Packing Co..... 94
Diamond Rubber Co..... 93

Valve Washers, Leather
Schieren Co., Chas. A..... 88

Valves, Ammonia
Chapman Valve Mfg. Co..... 86
Monarch Valve & Mfg. Co.... 84

Valves, Angle
Homestead Valve Mfg. Co.... 86
Lunkenheimer Co..... 4
Monarch Valve & Mfg. Co.... 84
National Tube Co..... 69
New Bedford Valve Mfg. Co.. 86

Valves, Back Pressure
Hughson Steam Specialty Co. 83
Jenkins Bros..... 65

Valves, Blow-off
Elliott Co...7, 81, 86, 88 and 98
Hancock Inspirator Co..... 85
Homestead Valve Mfg. Co.... 86
Jenkins Bros..... 65
Liberty Mfg. Co..... 7
Lunkenheimer Co..... 4
Powell Co., Wm..... 84
Simplex Engineering Co..... 83
Ziermore Regulator Co.....104

Valves, By Pass
Mason Regulator Co..... 84

Valves, Check
Greene, Tweed & Co., 80 and 4th cover
Jenkins Bros..... 65
Lunkenheimer Co..... 4
National Tube Co..... 69
Nelson Valve Co..... 87

Valves, Cylinder Relief
American Steam Gauge and Valve Mfg. Co.....60 and 61
Consolidated Safety Valve Co. 85
Lunkenheimer Co..... 4

Valves, Exhaust Relief
Alberger Condenser Co..... 97
Jenkins Bros..... 65

Valves, Free Exhaust
Schutte & Koerting Co..... 97

Valves, Gate
Chapman Valve Mfg. Co..... 86
Detroit Lubricator Co..... 79
Greene, Tweed & Co., 80 and 4th cover
Jenkins Bros..... 65
Lunkenheimer Co..... 4
National Tube Co..... 69
Nelson Valve Co..... 87
Ohio Brass Co..... 84
Powell Co., Wm..... 84
Pittsburgh Valve, Fdry. & Construction Co..... 86

Valves, Globe
Detroit Lubricator Co..... 79
Hancock Inspirator Co..... 85
Jenkins Bros..... 65
Lunkenheimer Co..... 4
National Tube Co..... 69
Nelson Valve Co..... 87
New Bedford Valve Mfg. Co.. 86
Ohio Brass Co..... 84
Pittsburgh Valve, Fdry. and Construction Co..... 86
Powell Co., Wm..... 84

Valves, Piston
Baker Valve Co.....113

Valves, Pump
Garlock Packing Co..... 9
Jenkins Bros..... 65
New York Belting & Packing Co..... 10
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 92

Valves, Reducing
Mason Regulator Co..... 84

Valves, Regrinding
Lunkenheimer Co..... 4
National Tube Co..... 69
Nelson Valve Co..... 87

Valves, Regulating
Hughson Steam Specialty Co. 83
Lunkenheimer Co..... 4
Mason Regulator Co..... 84
Nelson Valve Co..... 87
Steam Appliance Co..... 79
Ziermore Regulator Co.....104

Valves, Return Stop
Lagonda Mfg. Co.....3d cover

Valves, Safety
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashton Valve Co..... 86
Consolidated Safety Valve Co. 85
Crosby Steam Gage & Valve Co..... 79
Detroit Lubricator Co..... 79
Jenkins Bros..... 65
Lunkenheimer Co..... 4
National Tube Co..... 69
Pittsburgh Valve, Fdry. and Construction Co..... 86
Powell Co., Wm..... 84

Valves, Stop Check
Jenkins Bros..... 65
Lagonda Mfg. Co.....3d cover
Schutte & Koerting Co..... 97

Valves, Superheated Steam
Chapman Valve Mfg. Co..... 86
Consolidated Safety Valve Co. 85
Lunkenheimer Co..... 4
Nelson Valve Co..... 87

Valves, Tank
Nelson Valve Co..... 87

Valves, Throttle
Detroit Lubricator Co..... 79

Valves, Trip Throttle
Schutte & Koerting Co..... 97

Ventilators
Burt Mfg. Co..... 18
Ohio Blower Co.....109
Schutte & Koerting Co..... 97
Turbo-Blower Co..... 78
Vacuum Ventilator Co..... 69
Wing Mfg. Co., L. J..... 76

Vises
Armstrong Mfg. Co..... 84
Williams & Co., J. H.....106

Water Columns
American Steam Gauge and Valve Mfg. Co.....60 and 61
Elliott Co...7, 81, 86, 88 and 98
Huyette Co., P. B..... 83
Lunkenheimer Co..... 4
National Tube Co..... 69
Reliance Gauge Column Co... 89
Robertson & Sons, Jas. L.... 71
Wright Mfg. Co..... 90

Water Softening Apparatus
Dearborn Drug and Chemical Works 5
Harrison Safety Boiler Co.... 63
Kennicott Co., The..... 78
National Tube Co..... 69
Scaife & Sons Co., Wm. B.... 96

Welding Apparatus
Alton, Laine & Co.....106

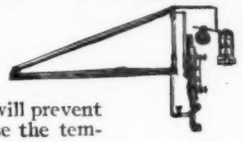
Whistles
American Steam Gauge and Valve Mfg. Co.....60 and 61
Lunkenheimer Co..... 4

Wrenches, Nut and Bolt
Trimont Mfg. Co..... 82
Williams & Co., J. H.....106

Wrenches, Pipe
Trimont Mfg. Co..... 82
Williams & Co., J. H.....106

Can You Always Rely On The Gage Glass?

Even if your fireman or water tender keeps a constant eye on the water glass, it is liable to be dirty or clogged up with sediment; so that very often the height of the water in the gage glass is not a true indication of conditions in the boiler. A Copes Boiler Feed Regulator feels the height of the water in the boiler; it operates on the expansion tube principle. Ask us for our book "P" on boiler feeding, which tells how the Copes Regulator works, and how its use will prevent low water and high water and raise the temperature of water from heaters.



No. 95

Northern Equipment Co., 408-418 West Indiana St., Chicago, Ill.

FOR SALE—CHEAP!

One 24″x36″—120 lb. steam pressure Greenwald-Brown Engine. In good condition. At present too small to pull load required. Address:

The Ault & Wiborg Co. Cincinnati, O.

The "Vacuum" Ventilator

Here is the simplest, surest ventilator on the market. It is a hollow ball with a *vertical outlet*, protected by a shield.

It has double the amount of working surface of other ventilators. Proof against storms and down-draughts. Only four parts—no swinging or rotating parts, no glass to break.

Write for Catalog.

Vacuum Ventilator Co. 84 Purchase St. Boston, Mass.

A few first-class agents wanted.

Get our Catalog

The St. John Indicating and Recording Steam Meter

Just How Much Steam Are You Using?

Do you know accurately how much horsepower is being developed to carry your loads? **The St. John Indicating & Recording Steam Meter** besides keeping a chart showing consumption by the hour, day or month, has a dial that indicates the amount at any instant. This meter is adapted not only to the measurement of steam, but also of air and all gases, water, and all fluids.

G. C. St. John

140 Cedar St., New York

The union with no inserted parts.

Don't Use Untested Unions

Don't spend time and money putting untested unions on your pipe lines. Untested unions generally leak. Leaks are not necessary *now*. Use THE "KEWANEE" UNION—the tested union—and secure air tight, non-corrosive joints. Turn to pages 90 and 91 of last week's issue.

National Tube Company, Pittsburgh, Pa.

Read Page 59

Suppose You Could Own A Trill Indicator And Have Somebody Else Pay For It?

How long would you be in ordering your Outfit?

We can't pay the *full price* of a "Trill" Indicator for you, but we *can* and *do* pay *part* of the total cost, taking it out of our own pockets in *real money*. For full particulars sign and mail the attached coupon.

$5 Down—$5 A Month

These are our easy payment terms. They bring the ownership of a splendid Indicator like the "Trill" right within your reach.

Any Engineer who is anxious to advance in his profession knows how necessary and helpful a good reliable Indicator is.

Any Engineer who takes the pains to study the "Trill" Triumph Indicator knows that a better, more accurate or more reliable instrument of its kind does not exist. Any Engineer who buys a "Trill" is investing his money wisely, in an Indicator of known merit. In the entire Indicator market there is not another Outfit which will give you greater satisfaction than the one we offer.

Our Indicator with Inside Spring, Case, two Springs, two Straight Cocks, Scales, etc., for steam, costs $40.00 (*Our special offer helps it pay its way*).

The same Indicator with the same equipment, but with Outside Spring (as shown) costs $55.00 (*Our special offer helps it pay its way*).

Don't delay. At any rate find out about our special offer—we have something of value to send you if you will mail us the coupon—something you can turn into actual money if you use it according to instructions.

Trill Indicator Co., Corry, Pa.

Please send me full details regarding Trill Triumph Indicators, and your selling plan.

Name .....

Address .....

.....

The "Eureka" Square Deal

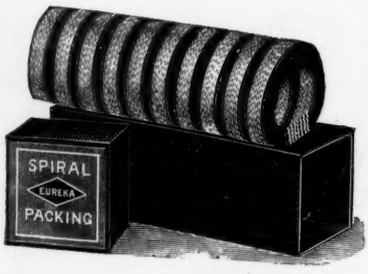
Published every other week in the Interests of Honesty in the Packing Business.

Vol. I. **By James L. Robertson.** No. VIII.

How Your Profession Has Progressed

One of the most amazing things in modern progress is the upward leap of the business of generating and transmitting power—your business.

I can remember when many engineers were "starters and stoppers," when most engines ran in a happy-go-lucky way, when most power plant owners were quite satisfied if the machinery ran without "too many" stops.



Eureka Spiral

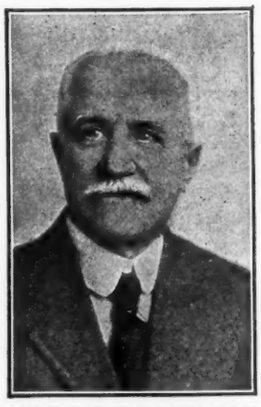
Look at the difference today. Engineers are men of complex knowledge, with big responsibilities; they know much of the *economical* side of their business—this getting of results at least cost. Engines have been brought well-nigh to a state of perfection and owners are demanding uninterrupted service. New machinery, new appliances, new accessories, have all come into use for the aim of getting power generated and transmitted efficiently and economically. This progress has been accomplished through the engineers of the world—and I take off my hat to them all.

When I realize what a tremendous power they have been and are for *progress*, I wonder that some of them permit themselves and are permitted by the majority to taint the whole profession by "graft" methods.

The "majority rules" only *when it votes*. This way of calmly accepting the fact that "graft" has fastened onto some of the members of your profession is no way to stamp out the evil before it spreads over the whole business and before it lowers the standing and pay of every man engaged in the engineering profession. That is what it will inevitably lead to if it keeps up.

Owners will pay engineers on the same basis that hotel men pay their waiters—"tips."

Fine way to class a self-respecting, intelligent engineer, isn't it? Who's guilty? The manufacturers who offer graft and the few "easy marks" who take it. Eureka Packing is one of some brands which is not sold on the "graft" basis. Every pound of it is good packing. Every pound is sold on merit—with nothing on the side. Every pound of it—outside New York City—is sold through good dealers who are not giving graft and who must meet the competition of grafting packing salesmen. Every pound carries with it a reputation for 30 years of "square dealing." Every pound is worth all that is paid for it. Every pound means better packing conditions, better service to owner and engineer alike.



JAMES L. ROBERTSON

I intend that every engineer I can reach through the printed word, and every owner shall know that here is a packing which is meritorious and "graftless."

If *that* is the kind of packing *you* want to buy and use, get aboard the band-wagon now—for we're all bound in the right direction.

You'll find it at your dealer's. If he doesn't carry it, send to us direct. We'll pay freight on 10 lbs. and over east or south of Omaha. We make 39 varieties for all purposes and the line comprises all styles and shapes.

Eureka Packing—39 Varieties—Have You A Catalog?

Eureka Packing Co., (Jas. L. Robertson, President.) 76-78 Murray St., New York